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IDENTIFICATION OF HUMAN BEINGS BY THE SYSTEM OF ALPHONSE BERTILLON.

BY
PERSIFOR FRAZER.

INTRODUCTION.

IN the early part of a sojourn of over a month which I made in Paris last fall, I called upon M. Bertillon, the inventor of the famous system of identification which bears his name, as we had been in correspondence for many years. I was most cordially received and taken by him over all the departments into which his identification service is divided, and when an eruption of crime in the "City of Light" during last summer and autumn which exceeded anything recorded in its annals, caused a constant demand for M. Bertillon's personal services, he most kindly placed at my disposition one of his trusted assistants, who seemed to be "primus inter æquales," inasmuch as to him was intrusted the duty of instructing the officers and men of the entire police force of Paris in the Bertillon system. This gentleman was still untiring in his efforts to place in my possession complete information of the subject up to date, including many very

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[NOTE.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

important procedures and methods which have never been published to this very afternoon. To this end, in addition to giving me detailed information of the apparatus for taking the measures, and the many various objects employed in teaching, he has written out quires of foolscap sheets giving the most intimate details of the work; and up to the present time an almost constant stream of very valuable charts, photographs, plans, and descriptions have been flowing from M. Bertillon's office in Paris to mine here. M. Bertillon expressed the pleasure it would afford him if I would make of my studies a popular lecture.

IDENTIFICATION OF HUMAN BEINGS BY THE SYSTEM OF ALPHONSE BERTILLON.

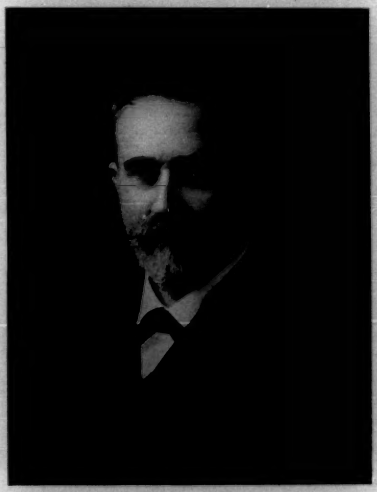
USE OF PURE RESEARCH.

In answer to the question, What is the value of a newly discovered *provisional* fact or law in science? (for science deals with no other kind), the illustrious name-saint of this Institute replied, "What is the value of a new-born infant?" As time goes on we get a specific reply to each specific query. This is notably the case regarding the subject with which Benjamin Franklin has so closely identified his name,—Electricity,—with its twin sister Galvanism. In the middle of the eighteenth century people regarded with awe the sparks which Franklin drew from his kite, and with child-like laughter the grimaces of the folk who took the spark in the ring with joined hands, the comical antics of the pith-balls, and the kicking of a pair of dissected frog's legs. The conservatives agreed that all of this was very imposing, or very funny, but what use was it? Franklin was the first to find an answer in the lightning-rod, which from that date to this, when properly constructed, has never failed to protect a building from the dreaded stroke. And in succession the telegraph, the electrotype, the motors which daily carry millions of people myriads of miles and countless burdens from the bowels of the earth and the sea to the surface, the incandescent and arc lights, which have almost superseded all other means of illumination, the Becquerel and Hertzian and Röntgen waves, children of electricity which penetrate human bodies and great timbers and limitless space calling aid to the ship sinking in mid-ocean, in man's service,—these are answers to that question, "Of what use is it?"

Probably in time every scientific discovery will have an equally definite reply of a similar kind. Alphonse Bertillon's system of judicial identification (or "Bertillonage") is such a response to the question, Of what use is anthropology?

ANTHROPOLOGY.

In the middle of the last century this science was founded, and Louis Adolphe Bertillon, the father of Alphonse Bertillon, was one of its sponsors in France. He was born in Paris in 1821, received his degree of M.D. in 1852, and prizes from the



Alphonse Bertillon.

Academy of Medicine in 1856 and 1858. After the revolution of 1870 he was made Mayor of one of the Arrondissements of Paris, lectured on anthropology in 1876, and was widely known as a statistician on demography, socialism, and medicine.

His son Alphonse was born in 1854, and doubtless through his father's influence was drawn to the study of social and

anthropological questions and hence to anthropometry and penology.

Whatever the incentive, these studies culminated in the adoption at the end of 1882 by M. Camescasse, Préfet de Police, and M. Vel-Durand, Secretary General, of the system conceived by M. Bertillon and proposed to the Administration in 1879. Subsequently M. Herbette, Director of Penitentiary Administration, extended it throughout France and warmly supported M. Bertillon in his presentation of the subject before the Penitentiary Congress of Rome, in November, 1885. The end sought by these officers was to facilitate the execution of the law of May 20, 1863, by destroying the pretexts of "first offence" and "somebody else" which had long served the old offenders.

SCIENCE AND ART.

In assuming that every actual discovery of a (provisional) fact or law will ultimately lead to a useful application, I am saying that every (provisional) law of science or group of such laws will lead to an art. It is well to remind ourselves here that the words science and art in the crude word-mills of current literature are confounded, and often distorted. In all that I shall have to say here I use the word Science as study of law; Natural Science as study of the laws of nature; and Art as the application of such studies to the practical use of man. Thus, from optics and physiology can be evolved the laws of color and color-sense; from geometry, the laws of perspective; but the painting of a picture is an art which applies these laws to a definite purpose evolved in accordance with laws of psychology in the painter's brain. The study of the human machine, or anatomy, the relations of parts of the human body to each other and the influence upon them of extraneous forces, or physiology, are sciences, but the application of knowledge of these things to the practice of medicine is an art. "Scientific" boxing, fencing, piano-, billiard-, and card-playing, training, cooking, etc., are the incongruous monsters of space-writers and may be compared to the centaurs and mermaids of our early progenitors, in that they join things together which are never joined in nature. Perhaps it would be more polite to call these vulgarisms of speech metonymy.

The science of anthropology has for its study man in all his

attributes and qualities, physical and psychological, but the first or physical characteristics are those which chiefly concern us here because it was through the study of these that Bertillonage was evolved.

BERTILLON SYSTEM ACCURACY OF OBSERVATION.

The system of identification of M. Bertillon, which has proven so useful to mankind that half or more of the nations of the earth have adopted it, is not a discovery in the same sense as those of Copernicus, Newton, Laplace, and Darwin, though like them in reaching its goal by synthesis of well known and even commonplace facts, but if the aphorism be true that genius is the capacity to take infinite pains then Bertillonage is an example of the highest genius, for its successful application depends upon a delicate unperturbed appreciation of physical sensations on the part of the observer, a scrupulous accuracy in recording observable data, and the use of all the precautions known to original investigation by repetition of measurements and readings to avoid possible error. On this subject M. Bertillon says in his "Identification anthropométrique" of 1893, . . . "These measures derive their entire value from being accurately taken. If a means could be found for reducing the error of each recorded observation by one-half in each of the eight different measurements, the error of identification would be 1 divided by $8 \times 2^8 = 1 \div 2048$."

Therefore the whole marrow of Bertillonage is detail,—minute detail,—and close readings. It is this fact which makes it difficult to present the subject entertainingly to a popular audience. I shall rather endeavor to sketch in outline what it is the object of the system to accomplish, and the means employed.

ANTHROPOLOGY.

Broca, a member of the first Société d'Anthropologie, of Paris, proposed a color scale for describing the eyes and skin of different races of men.

The characteristics which he regarded as most valuable in distinguishing races were, first, the color of the skin, and, second, the structure of the skull, and their importance in the order given.

According to Retzius's method, very generally adopted by anthropologists, the longer diameter of the skull from front to back is assumed as 100. If the shorter diameter measured above the ears is less than 80 on this scale the skull is called dolichocephalic (long-narrow headed); if more than 80, brachycephalic (short or round headed). From 75 to 80 in the transverse diameter he called mesocephalic. Negroes have 72, Europeans 78, and Tartars 88, in this measure. Blumenbach recognized five races, viz.: Caucasian, Mongolian, Ethiopian, American, and Malay (E. B. Tylor, "Encyclopædia Britannica").

The application by M. Bertillon of these methods was for the identification, not of great groups of the human family,—races,—from each other, but of an individual from every other individual, and arose from the urgent need of the law courts to know whether they were dealing with old offenders (recedevistes), or whether an arrested man actually had not been previously before them.

DIVISION OF SYSTEM.

M. Bertillon's system is divided into, first, a means of identifying an individual with absolute certainty, from careful measurements taken by skilled agents, and, second, a ready means of recognizing an individual in a crowd from a description or from observations previously taken. One supplements the other, while each is useful independently of the other.

The principle upon which the measurements are based is that no things are absolutely identical, however similar they may seem. This is especially true of organic objects which grow, because it is unthinkable that two different and separate beings could be, during a number of years, subjected to exactly the same forces, and should present to these forces exactly the same resistances. Whatever it be, whether two coins struck from the same die, twins who have been fed and nurtured similarly, even two drops of water taken from the same source, a sufficiently minute examination will inevitably disclose differences which will be greater and more numerous the more searching and careful is the investigation. It is only necessary then to obtain a sufficient number of data from each individual to place upon record a description which will differ from that of any other individual analogously made.

The printed pamphlets which I have obtained from M. Bertillon containing statistics of the working of the system are the following:

"Extrait de l'annuaire statistique de la ville de Paris pour l'année 1887. Notice sur le fonctionnement du service d'identification de la préfecture de police suivie des tableaux numériques résumant les documents anthropométriques accumulés dans les archives de ce service, par Alphonse Bertillon, Chef du Service d'identification, Paris, G. Masson, éditeur, libraire de l'Académie de Médecine, 120 Boulevard St. Germain, 1889."

This contains besides a general description a series of tables of the greatest scientific interest, giving the "Mean dimensions of each measurement by age," tables *A* and *B*, with the results of the calculation with the elimination of one-half, nine-tenths, and total elimination. These same calculations are carried through all the succeeding tables. Tables *C* and *D* are "Mean dimensions for each measurement of a group of heights at intervals of 5 cm. (Parisians from 21 to 44 years)." Table *E*, "Given a measure (of some dimension), what is the corresponding height (Parisians from 21 to 44 years)?" This table is divided into span, body measure, crotch to heel, fore-arm, left foot, head-length, head-breadth, left middle finger; little finger; length of ear; color of eye (?). Table *F*, "Given the length of foot and of the fore-arm, what is the corresponding height?" Table *G*, "Given the lengths of foot and of the left middle finger what is the probable height corresponding?" Table *H*, "Given the head-length and breadth what is the probable height corresponding?"

The other pamphlet is entitled, "Bibliothèque d'anthropologie criminelle et des sciences pénales, l'anthropométrie judiciaire, à Paris en 1889, etc." Lyon, A. Storck, éditeur, 78 rue de l'hotel-de-ville, Paris; G. Steinheil, éditeur, 2 R. Casimir-Delavigne.

A third, now out of print but which I consulted in Paris, was "Identification anthropométrique. Instructions signalétiques," Alphonse Bertillon. Nouvelle édition, 1893.

A newer edition of this work is promised within the year. What I bring before you to-night is not confined to the matter contained in the pamphlets I have mentioned nor any other printed information. M. Bertillon himself and his able assistant, M. Bertrand, have furnished me with a great deal of new material up to date which I have supplemented by notes and observations made in the rooms of the Service of Identification.

I do not in the least blame M. Bertillon for not putting in print the details and statistics of his service to date. There are criminals, perhaps the most important destined to be captured by his admirable methods, who are as intelligent as he, and who would gladly avail themselves of full statistics of his methods to escape justice. Not only in France is this true but so universally has this system been acclaimed and adopted by foreign nations that the loss to human justice would be incalculable should his minute details of procedure be so perfectly mastered by rogues that they could "take measures" also to defeat them.

There is an interest personal to myself in the history of M. Bertillon's system.

STUDY OF HANDWRITING.

An accidental connection with a case involving the examination of handwriting in 1878 turned my attention to the subject, and a few months' work in my leisure moments convinced me that it could be treated by purely scientific methods. Unknown to me M. Bertillon had commenced in 1872 (his nineteenth year) the application, to a larger and more important field, of methods in some respects similar to those I adopted, and had presented them to the authorities in 1879, the year when my first essays were made. I had employed averages of the greatest possible number of cases to avoid the error of accidental variations just as he had done a few years before. His methods like mine are anthropological, but whereas M. Bertillon employs exclusively the concrete or anthropometric, my own results are based upon the psychological branch of this science; that is, upon thought and will-power translated into action, which leave traces behind them.

SELECTION OF POINTS.

The first thing to consider when contemplating a rigorous description of a human being is what data are most serviceable, because least likely to vary, and least capable of being altered.

Only a long practical experience in anthropometry could decide this question.

In the early stages of Bertillonage many measurements were taken which are now entirely discarded.

It is evident at the first thought that the most permanent data will be found in those parts of the body which undergo the least change; in other words, the bony structure; and of all these the skull, which from an early age, in spite of its twenty-two component bone-plates, is virtually a single large bone, proves the most available for identification because important artificial alteration of its dimensions is almost or quite impossible. The pivotal point of the Bertillon measurements is therefore the skull and the relation to each other of its anteroposterior and transverse diameters.

Other measures used to differentiate the individual are the length of the left foot, the length of the middle finger of the left hand, the length of the left forearm from elbow to middle finger tip, the height in a standing position, and seated, the span of the extended arms, and the length and breadth of the right ear. The measurements in these and all other cases where bony structure is involved are made from points where the bone is covered by a minimum of integument, and no fat nor muscle interposes between it and the measuring instrument.

The measurements of the bony structure are taken from the left side, preferably, because most people are right-handed and the members of the left side suffer least from injuries.

These measures constitute the more important part of the Bertillon description, and furnish the means of classifying the records of an individual in the box files, which latter form one of the most astonishing parts of the whole system and one without which the others would be absolutely valueless.

But these are only a few of the observations and measurements actually taken when it is desired to have a complete record of the individual. With the increased experience which the practice of this system for twenty-six years has brought, various additions to the armory of identification have been made, and notably two of the utmost importance, viz., the study of the finger-prints, first systematically applied in modern days by Sir William Herschel when he was "Collector," or chief administrator, of the Hooghly district in Bengal, and presented to the

scientific world, with the thoroughness and accuracy which distinguish all he has done, by Francis Galton in 1888. The other, a careful determination developed by M. Bertillon of the shades of color exhibited by the human iris, classified by the increasing intensity of its yellow-orange pigmentation. While the accurate description of this characteristic requires an extremely delicate color sense and great experience on the part of the describer, it furnishes a datum, M. Bertillon asserts, as unchangeable as the dimensions of the skull.

A mounted chart of these colors is beside me. It can be procured by application to M. Bertillon.

PORTRAIT PARLÉ.

But besides these principal features of the classified description of an individual, M. Bertillon has added a large number of others for the use of the police where accurate measurement is out of the question but recognition on the street or in a crowded room is the object. These are the features of what he has aptly called his "portrait parlé" or described picture which can be telegraphed from one end of the country to the other, and thus enable a distant policeman to recognize and apprehend a fleeing transgressor.

In this described picture the points to which the attention of the detective is directed are the following:

1. NOSE: Profile of the line of the ridge of the nose, is it (*a*) concave, (*b*) straight, (*c*) convex, (*d*) arched or hooked?]

2. EAR LOBE:
   - (*DEQ*) descending or square
     - (*TRA*) furrowed.
     - (*SEP*) the lobe separated from cheek.
   - (*CAR*) antitragus concave or straight
   - (*SA*) antitragus profile prominent.
   - (*VEX*) lower fold convex
   - (*X*) absence of preceding characteristics.

3. EYE: (*j*) yellow, (*or*) orange, (*ch*) chestnut, (*mar*) dark chestnut, (*as*) azure, (*i*) intermediate violet tinge, (*ard*) slaty, (*v*) greenish.

4. HAIR AND BEARD: (*bl*) blonde, (*ch*) chestnut, (*rx*) brownish red, (*grs*) grisly, (*cl*) light, (*m*) medium, (*f*) dark.

SPECIAL MARKS.

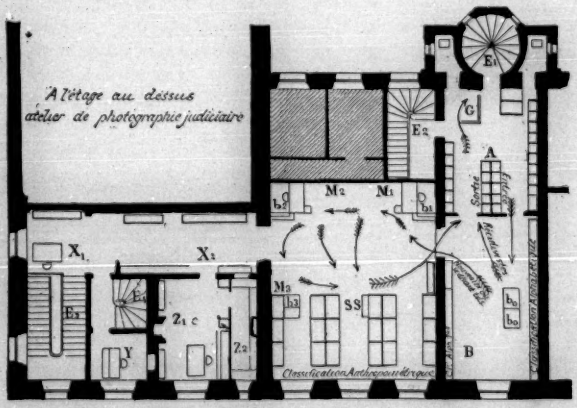
Following these in the D.K.V. book shortly to be described there are one hundred abbreviations to one or two letters of words to describe cicatrices, moles, mutilations, boils, sores, etc., which may be of great value either for recognizing an individual or for confirming the probability of his correct identification.

SAINTE CHAPELLE.

A word or two may be here devoted to the location of the service of identification in Paris.

On the island of the city where the first stronghold (then called Lutetia) was built in the time of the early Roman empire,

FIG. 1.



there stands a noble old palace, which served during the middle ages as the home of the French kings. Close alongside of it is one of the most beautiful specimens of Gothic architecture in the world, the Sainte Chapelle, built by St. Louis to house the relics he brought from his ill-starred crusades, and especially the crown of thorns sent from Constantinople. This wonderful little architectural gem is buried in the shadows of the greater buildings which surround it, the immense Palais de Justice, and the depot, or central police station, of the préfecture de police.

This enormous palace of justice has been extended and partially reconstructed, and on its west side facing the Place Dauphine it presents a superb Greek façade which was erected during 1865–70. On entering the building one is bewildered by its vastness. Avenues as broad as streets and bearing names like streets traverse it from east to west, and are intersected by cross avenues through which one may see the advocates darting hither and thither in their gowns and academic hats. The corridor from which one ascends to the rooms which are employed by the service of identification is called that of "Sainte Chapelle" because only separated from that unfortunate and beautiful structure by the south wall and the rooms thereto adjacent.

It is difficult to imagine a bureau better situated for its purpose, close beside the depot which receives all the prisoners arrested for petty and grave offences within the department of the Seine, and communicating with it by a private door and stairway. The depot is less a prison than a vast central post where all the thieves, mendicants, vagabonds, etc., arrested the day before in the department of the Seine, await their appearance before a court of justice.

The only exceptions are those who are arraigned before the Courts "in a state of liberty" for minor offences and condemned to a few days of prison. This category seldom contains professional malefactors. Their detention in the depot does not exceed twenty-four hours, during which time they are "Bertillonized" to the number of 80 to 150 or more a day. This procedure is effected in the early morning, so as not to interfere with the examinations before the magistrates. Only three or four hours are therefore available for taking measurements of this great crowd. Six or seven at a time are brought by agents of police up the spiral staircase to the rooms where the measures are taken. On their arrival they take their places in twenty-six little stalls arranged along the wall and in the middle of the room, and here remove a part of their clothing and foot-gear, retaining only their shirts and trousers.

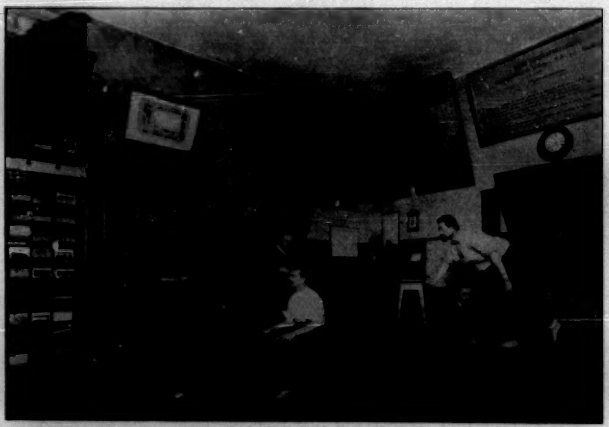
FIRST TEST.

Each hangs his garments on the nails with which the stalls are furnished until the measurements are completed and passes directly to a connecting large room in the rear furnished with shelves holding index files in boxes called cabriolets, reaching from the floor to ceiling, and containing the Bertillon registers of those who have been previously measured, classified *alphabetically* by the names and social conditions they have given.

In this room the first test is made. About half of those arrested give their real names, and for such the inquisition is ended as soon as the measuring instruments are adjusted to the values recorded and applied to the respective objects of measurement for verification, and a rapid examination is made to verify the peculiar marks recorded on each card.

This identification is confined to the two measurements of the head with callipers fixed successively to the figures given in the description already on file. These two data taken and cor-

FIG. 2.



roborated to a millimetre ($^1/_{25}$ in.) are amply sufficient to determine whether or not the prisoner has told the truth.

It is thus at once seen whether the same individual is present and if so no further measurement is made.

The agent marks "idf" (identified) on the back of the card with the new data, and signs his initials and the prisoner returns to the room he has just left and re-clothes himself.

In the case of a young person whose growth might cause a discordance with the data obtained, or of an offender who has not been arrested more than once before but of whom it is important to preserve the record because he is likely to be or become an habitual criminal, the examiner marks "vrf" instead of "idf," which means that the verification has been made of all the points

noted in the first description. The figures then recognized as erroneous are replaced by new and accurate data. Where there is no change the mark of equality (=) is entered, meaning that the complete verification has been made.

With adults the complete verification of all data is made only at long intervals, say ten years, whereas on the contrary minors are subjected to it at each arrest even if the interval be but a few months.

FIG. 3.

When the same offender has been identified five times he is banished.

Only those who are for the first time arrested or who deny their identity are passed to the second room of the service.

As rapidly as possible those who are subjected to a further examination are called into the large adjoining room where three separate sets of measurements can be undertaken at the same time. In each case the same agent obtains the anthropometric measurements, the portrait parlé description, and the peculiarly

characteristic marks, which are recorded by a clerk occupying an elevated desk very much as the measurements are taken in the better class of tailor shops.

Some observations may be permitted concerning the way in which the measures are taken.

The Long Diameter of the Skull.—This is obtained by means of adjustable callipers with a binding screw to fix the arms at

FIG. 4.

any position. The measure is made from the cavity at the root of the nose to the point of greatest protuberance of the occiput. Two measures are made to control each other.

Transverse Diameter of the Skull.—This is taken by means of the same callipers and is the maximum distance apart of the parietal bones which are situated above the superior border of each ear. The measurement is rather difficult because there is no fixed point of departure like the cavity at the root of the nose,

and care must be taken not to displace the arms of the callipers on both sides of the head at the same time. An excessive breadth of head indicates the brachycephalic type. The breadth of the head of an adult male in France varies between 153 and 158 mm. (6.06 to 6.22 inches).

Length of Middle Finger (or of Little Finger).—The two fingers are measured by means of the same sliding rule, the finger being first bent until it is at right angles to the back of the hand. It is taken to half a millimetre ($^1/_{50}$ inch).

It follows necessarily that in order to secure this accuracy neither fat nor muscle must intervene between the bone and the

FIG. 5.

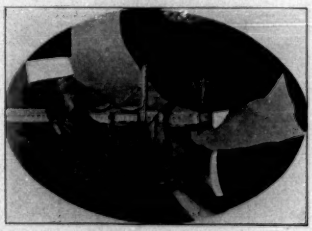
plane of the instrument. This is most readily accomplished when the hand forms an angle of about 137 degrees with the wrist and the finger a right angle with the back of the hand. The measurement is, of course, from the bone of the first joint to the tip of the finger.

Span.—The graduated rod for the span is also fixed horizontally to the wall. A vertical strip is fixed to the wall midway between two height measures. The end of the middle finger is placed against this, the arms are extended horizontally and that farthest from the strip covers a part of a rectangular board on which vertical lines indicate centimetres. The edge of the board at which the centimetre marks begin is just one metre from the strip above described. The measure is to the extremity of the middle finger of the other hand.

Left Forearm.—A wooden horse 1.19 M. (+ 3.8 ft.) high supporting a board 0.8 M. (+ 2½ ft.) long and 0.25 M. (+ 8 inches) broad serves for a rest of the arm. The subject is made to take a position leaning slightly forward and to place the bare forearm on the board. A shoemaker's measure is then adjusted so that the fixed end touches the bone at the elbow and the movable part the extremity of the middle finger. The average length of forearm for an adult in France proves to be 44.5 to 45.3 cm. (17.46 to 17.79 inches).

Height.—The subject is not placed so that his back is against the fixed metre staff attached to the wall, but to one side. The measuring arm projects toward the subject and records on the

FIG. 6.



rod attached to the wall. This enables the measurer to see that the subject is standing on his heels, the legs together, the back and occiput against the wall, and the figure perpendicular to the floor. The reading is to the nearest millimetre ($^1/_{25}$ inch).

Body Length or Bust.—What is called the bust is the trunk and head or the height of the figure in a sitting posture.

The graduation for this measurement is from 0.70 M. to 1.20 M. (1.55 ft. to 3.9 ft.).

The Right Ear.—It is of course preferable to measure the feature given in the photograph of the subject, which is on the right side. The subject's head is inclined to the left and backward. The length is obtained with the aid of a sliding measure from the upper to the lower edge of the ear, the latter called the *lobe*. The average length of right ear for a French adult is 63 mm. (2.48 inches).

The Examination of the Left Eye.—The eye is a means of identification as important, in M. Bertillon's estimation, as the marks of the finger prints. The color does not change with age. So far as its color is concerned, M. Bertillon asserts, the eye is unchangeable from birth to death. The conditions under which it is observed may change, and this may lead to a false impression. It ought never to be ex-

FIG. 7.

amined in a false light. The subject whose eye is to be described should receive a strong light (but not the direct rays of the sun) full in the eye. M. Bertillon has made a table of seven categories of color which are beautifully printed in chromotypogravure by the Maison Gillet of Paris, copying paintings in oil colors from models in nature by Felix Geoffray under M. Bertillon's direction, and have been mounted on a card. The categories are based on the increasing intensity of the yellow-

orange pigment. The pigment is a reddish- or brownish-yellow animal matter which gives to the eye diverse tints. When the pigment increases in quantity in an iris, the eye from the point of view of its color, and of the number in its class, increases also. In other words, the more pigment an eye contains the more it appears dark and close to the extreme type of pure horse-chestnut color. Eyes called unpigmented are not deprived of all color,

FIG. 8.

but are uniformly blue, and the opposites of the pure horse-chestnut brown color. This type of eye is found among the Slavs, and the people of the North, the other type among the negroes, the Arabs, and more generally the dwellers in the South.

Between these two extremes are intermediate classes numbered 2, 3, 4, 5, and 6 which indicate in the order named the eyes in which the yellow is that of flowers of sulphur (2), rind of lemon or orange (3), the color of the shell of a chestnut dry

and powdery (4), the color of horse-chestnut in rings but not covering the entire iris (5), the color of the horse-chestnut of the Indies with a tinge of green (6), and finally, the color of the shell of a ripe and fresh horse-chestnut with velvety surface.

The Left Foot.—All the measures of the members of the body are taken on the left side; first, because the left side is that opposed to the right of the operator facing the subject and usually easier for him to reach; and, second, because most people being right-handed there are fewer wounds, amputations, and other results of accidents on the left side than on the right; and this fact is important when one reflects that the measurements are almost exclusively of the bony structure. To obtain the maximum length in measuring the foot the subject stands on a stool on one foot, leaning forward. This brings the entire weight on the foot and forces the toes forward to their complete extension. The instrument of measurement is the extensible shoemaker's rule, one part being placed against the heel and the other against the point of the great toe. The average length of the left foot in French male adults is from 25.5 to 26.1 mm. (10 to 10.25 inches).

The Bi-zygomatic Diameter.—This measure has in part replaced that of the right ear. It is taken by means of the same callipers, between the osseous bands which terminate above the auditory canal and behind the cheek bones. The ends of the calliper must be kept horizontal and the measurer should be as close as possible to his subject. Neither hair of the head or face, nor fat prevents the accurate estimation of this diameter, which increases and diminishes with the other cephalic measurements. In French adults it varies between 137 mm. and 138 mm. (about 5.39 inches).

As an example of how the divisions very small, small, medium, large, and very large as applied to the ear, are distributed in M. Bertillon's office the following will be of interest:

Very small	55 mm.	(2.17 inches)
Small	58 mm.	(2.28 inches)
Medium	63 mm.	(2.47 inches)
Large	70 mm.	(2.74 inches)
Very large	75 mm.	(2.94 inches)

Particular Marks.—These are sought on the arms, and trunk especially, but any scar constitutes such a mark and may be of great value in determining identity. Whether tattoo, cicatrix,

tumor, or common mole, each of these kinds of marks is furnished with an abbreviated symbol of a couple of letters and is carefully measured by a millimetre rule from the nearest fixed objective point on the body or limbs.

CONVENIENCE OF RECORDER.

M. Bertillon rates very highly the advantage of saving from the annoyance of making notes the agent who is making measurements and observing the characteristics of the subject. He also attaches great importance to his system of abbreviations which saves much unnecessary writing.

FIG. 9.

Of these measurements and descriptions, in Paris one copy is made, the rough notes being used for the alphabetic, and the copy for the anthropometric collection of the capital. In Lyons and Marseilles (which keep services of records like that of Paris) three copies are necessary: one for the city where they are taken, and two for Paris.

As soon as the data are obtained the subject is sent with his record-slip to the agent of the anthropometric section who attends near the large stacks of records in the rear of the measuring room. This officer, whose eye is trained to run rapidly over the record-slip, notes at once whether any important datum has been

omitted, either there or on the back of the slip containing the prisoner's account of himself. In case of any omission he sees that it is supplied, and then classifies, by putting into their respective places, the records of the persons examined.

> The subjects of examination having completed the cycle required of them return to their stalls and dress themselves. As anthropometry furnishes sufficient means of identification to detect an old offender (measured after reaching maturity) the préfecture of police only requires photographs of those under 21 years. If over that age only those of whom the police wish a portrait to facilitate or hasten an investigation are conducted to the photograph gallery.
>
> As the separation of the persons in the rooms of the identification judiciaire is not absolute, the chief of the préfecture de police takes care to send there in different squads the various individuals inculpated in the same affair. Dangerous criminals or those persons of whom a very particular description is desired, are sent to the measurers during the afternoon.

The service comprises two sections: (1) of anthropometry, and (2) of photography.

The employés of these two sections number eight agents, of whom one is a brigadier detached permanently from the service of the department of safety, a principal inspector having authority over both, and the chief of the service M. Bertillon.

To be continued.

SCOTCH FULLER'S EARTH.

There are many varieties of this material varying both in chemical composition and in physical qualities, and while the former is well known from the result of analysis the latter have never been very clearly understood. Consequently chemical analyses are of comparatively little value in determining for what purpose the earth is exactly suited, which can only be ascertained by practical experiment and experience.

The manufacture of fuller's earth is carried on in various ways according to the variety of the material and to the purpose for which it is required. The simplest process is that in which the crude earth is dug and kiln-dried, while it may be further treated by being ground to a fine powder, say 120 mesh, in which latter form it is largely used by manufacturers for refining purposes. In other cases the crude earth, after being mined or dug, is ground and washed, sand and other impurities being taken out by specially constructed sand traps and revolving sieves, then deposited in large tanks and afterwards kiln-dried, when it takes the form of lumps and is used for cleansing and fulling cloth, etc. The lump earth is also reground, purified, and reduced to different grades and classes of powder according to the purposes for which it is required.

In Scotland the only known deposit of fuller's earth is at Keltie, Dunning, and Perthshire, where there are large quantities of different kinds.

Consular Report.

ELECTRICAL SECTION

(Stated meeting held Thursday, February 18, 1909.)

TUNGSTEN AND OTHER LAMPS.

BY
GEORGE LORING.

WE will briefly consider the manufacture and performance of the electric illuminants, having filaments operating in vacuo, which are proving commercially successful to-day in this country. They are known as carbon, gem, tantalum, and tungsten lamps.

The carbon lamp, at the time of its introduction commercially,—1879,—had a so-called efficiency of less than 4 w. p. c., which, in the course of sixteen years or so, was improved to 3.1 w. p. c. Then, for more than ten years, this illuminant practically stood still as far as decreasing its current consumption was concerned. Finally, in 1905, a decided improvement took place, the efficiency of the lamp being increased to 2.5 w. p. c. In less than twelve months after this advancement had been made, manufacturers brought out and placed upon the market the tantalum lamp, with an efficiency of 2.2 w. p. c., which, within a short while, was changed to 2 w. p. c. On January 1, 1908, an American-made lamp, having an efficiency of 1.25 w. p. c., with filaments constructed of tungsten, was offered for sale in this country.

It will be seen that during the past four years the electric incandescent lamp has increased 60 per cent. in efficiency, although during the twenty-six years preceding that time the improvement along the same line was approximately only 25 per cent.

MANUFACTURE OF CARBON LAMPS.

We will consider the manufacture of the illuminant known as the carbon filament lamp.

Building the Filament.—Cotton is placed in an acid, changing it into a mass form a trifle thicker than molasses. This is put into

a bottle, and forced through a small outlet in the bottom of it, in thread form, by an air pressure from above, falling into a hardening mixture contained in a jar. It then goes through another process, after which it is washed free from acid in water. Next it is wound on drums and left to dry. While doing this it shrinks to about one-third of its first size. After being taken from the drums it is gauged for size, wound on forms and placed in a graphite crucible. It is then baked at a very high temperature for a few hours, unpacked and gauged by resistance per inch, cut to proper lengths according to the voltage and candlepower for which it is intended, treated in a gasoline gas for resistance by apparatus which automatically cuts out when the correct point is reached, tested for spots, counted and packed into boxes ready to go to the mounting room.

Leading-in Wires.—The leading-in wires of all lamps have a certain amount of platinum welded to the ends sealed within the stem. The platinum is cut automatically by machine. The wires are cut by hand. The copper is welded to the platinum, the former melting while the latter does not. Inspection takes place. The leading-in wires are then packed and are ready for use.

Stem.—A stem is made from a flange tube which has previously been sorted from others for diameter and thickness. This is necessary as the dimension of the stem ofttimes varies with the size and style of lamp into which it is going. We will select one flange tube (Fig. 1) and follow it through the factory.

It goes to a machine which automatically puts a flange upon it (Fig. 2). It is then taken to another device and placed in same, flange up, the other end resting upon a block. Two leading-in wires 3 inches or more in length with platinum tips are placed in the flange tube. The platinum end of each wire rests in a separate depression in the above-mentioned block. Gas flames are directed against the tube, covering the last ¼ inch of the end which is not flanged. Jaws come up automatically and press this section of the tube together, sealing in the copper wires in such a way that the platinum starts about ⅛ inch from the end of the seal and protrudes for an equal distance; at the same time, when an anchor is used, it is automatically inserted into the glass. The stem is then annealed, inspected for quality and if satisfactory is sorted into the proper stock division. If the stem has an anchor it is given to an operator who cuts

it to the proper length, and if necessary bends it at the end (Fig. 3).

Mount.—The carbon is now mounted upon the stem, this being done by connecting the filament to the proper wire terminals or supports. A graphite and suitable binding material paste is used in this work (Fig. 4). The mount is then straightened and inspected for every conceivable error. If satisfactory it is baked in an oven in order to make the joints absolutely secure. We will now give our attention to the bulb into which the mount is ready to be placed.

Bulb.—The appearance of the bulb when received by the lamp manufacturer is shown in Fig. 5. Tissue paper surrounds it.

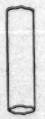


FIG. 1.

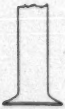


FIG. 2.

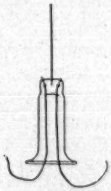


FIG. 3.

FIG. 4.

This is removed and the bulb with others is placed in a tray, clamped down to hold it fast and submerged in a tank of water. After being thoroughly washed it is allowed to dry naturally. It is then moved to a machine where a hole is made in the centre of the large end. This is accomplished by applying a pointed gas flame to that spot and sending an air pressure down through the neck. What is known as the top tube, shown in Fig. 6, is then joined to the bulb where the hole has been made. This is called the tubulating process and the result is to be seen in Fig. 7. This tube is about 1⅞ inches in length and is cut with many others from a long one in a separate department. The tubulated bulb, neck down, is next placed in a blowing off machine which cuts the neck to the proper length and with a pressure of air which is passed down through the tube and bulb makes a flare at the end of the neck (Fig. 8).

We are now ready to place the mount (Fig. 4), which we left a few minutes ago, within the bulb (Fig. 8), sealing them together.

Sealing-in.—The mount (Fig. 4) is placed upon a machine and the bulb (Fig. 8) is set over it. The former is adjusted so that the flange on the stem properly meets the flare of the bulb.

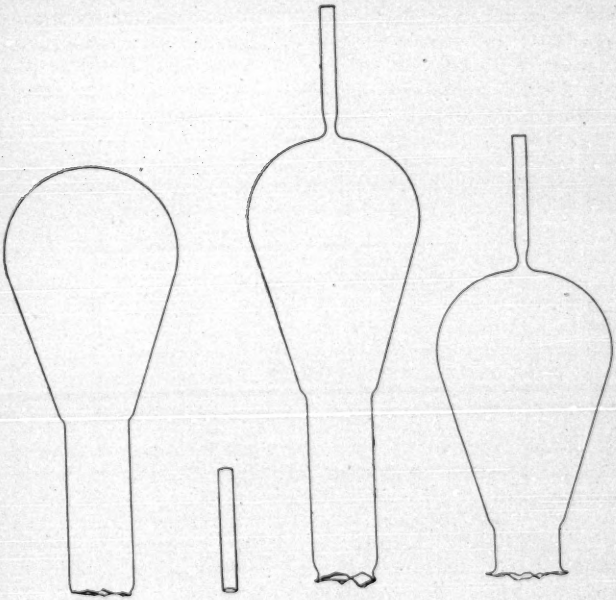


FIG. 5. FIG. 6. FIG. 7. FIG. 8.

The stem and bulb in this position are put into what is known as the first fire, to be warmed up. They then go into the final fire and the glass of the flange and the flare of the bulb are hermetically sealed together (Fig. 9). The lamp is now removed from the machine and a pair of pliers are inserted into the stem centring the filament and forming a ridge on the outside of the

seal, making it more secure and creating an anchorage for the cement used in basing. The lamp is now annealed and afterwards inspected.

Exhausting.—Producing a vacuum within the lamp and sealing or tipping the tube through which the exhausting takes place is the next operation. First, the inside of the top tube is painted with a phosphorus preparation. The lamp is then heated in an extremely hot flame to drive the gas from its sides. Next it is

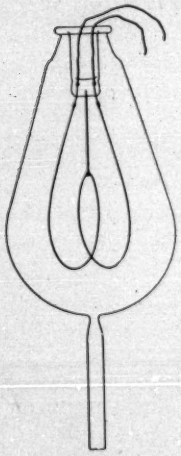


FIG. 9.

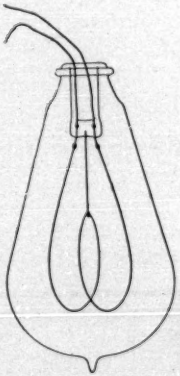


FIG. 10.

FIG. 11.

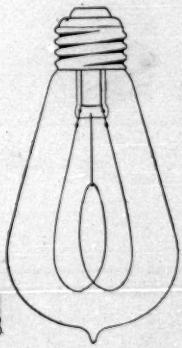


FIG. 12.

connected to a preliminary pump and the air is fairly well exhausted. Following this it is attached to a second pump which has an ability to produce a higher vacuum and practically all the air is extracted. While on the second pump the lamp is lighted. The pumps are shut off and the gas flame is directed against the tube heating the phosphorus matter which gives off a gas which combines with the residual gases in the bulb, forming a solid precipitate so small that it cannot be seen. At the same time the exhaust tube is fused off a short distance below the bottom of the bulb, leaving the tip which is seen on the majority of

lamps (Fig. 10), and the current is shut off from the lamp. The lamp is now inspected for spotted filament, vacuum, and all mechanical and electrical defects which could possibly have taken place up to this point. It is then ready for the photometer room, that is, to be tested to determine the voltage at which it will give the candlepower for which it is manufactured. Upon this being ascertained it is placed in a tray with similar lamps and left in a certain section of the factory until the tray becomes full, when it is put into stock. Ordinary 2 to 24 candlepower lamps are sorted fifty to a tray; with larger sizes there are naturally less.

Finishing.—When an order is received lamps of proper candlepower voltage and current are taken from the stock room and again tested for vacuum. A felt washer and a license label are then placed in the stem. The former keeps the leading-in wires apart and also prevents cement from getting in. The lamp is again tested for spots and for selection by being burned in series. This would readily show if any lamp had become mixed. The next step is the basing. A shellac cement is placed in the base (Fig. 11), which is put over the neck of the lamp, one of the leading-in wires coming out through the centre of the tip of the base. The other leading-in wire protrudes between the lamp and the shell of the base. The lamp is then placed in an oven and the base thoroughly baked. The leading-in wires are then soldered to the base and the lamp is cleaned by having the lower three-quarters of it placed in boiling water containing whiting. It is then dried with paper and the base is cleansed. The lamp is then labelled, tested for vacuum, straight base, proper soldering, cleanliness and all mechanical and electrical defects. If etching is desired it is done at this time. The lamp is also frosted at this stage, label of course not having been put on. Fig. 12 shows a carbon lamp completed. The lamp is now ready for shipment.

Sixty-eight people at least handle a carbon filament incandescent lamp while it is in the process of construction, no two people doing the same kind of work. This does not include the parties having charge of inspections, neither does it mean that only that number of operations are necessary. Some of the help take charge of a lamp while it is going through several steps in the course of completion.

GEM LAMPS.

The chief difference in the manufacturing make-up of the gem lamp compared to a carbon is that the thread of the former is baked in an electric furnace before and after being treated, giving it the appearance and electrical characteristics of a metal.

MANUFACTURE OF TANTALUM LAMPS.

The manufacturing process of the tantalum lamp (Fig. 14) differs from that of the carbon lamp in the following respects:

FIG. 13.

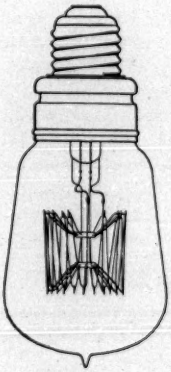


FIG. 14.

The filament, which is drawn from tantalum, a metal, is of very low resistance, and therefore has to be extremely long. It is found convenient to support it upon spiders, attached to a glass tree, which is connected to the stem where the anchor in a carbon lamp is found (Fig. 13). The parts of the leading-in wires composed of platinum do not protrude from the end of the stem, but are sealed therein and are joined to small copper wires with tubed ends, which extend from the stem for an inch or so and into which are inserted the ends of the tantalum filament, a firm connection being made by pressing the tubed copper wires together. No paste is used in making the joint.

MANUFACTURE OF TUNGSTEN LAMPS.

The manufacturing process employed in producing tungsten lamps is similar to that adopted in building carbon illuminants, excepting in the construction of the filament and the mount.

Tungsten is an acid-forming metal, found in the following ores:

Wolframite,—in the form of tungstate of iron and manganese.

Tungstenite or shellite,—in the form of tungstate of calcium.

Scheeletine,—in the form of tungstate of lead.

Wolframine,—in the form of tungstic acid.

Tungsten is also frequently found in tin ores.

The tungsten used in manufacturing lamp filaments is secured, as far as the writer knows, entirely from wolframite, and is received by the lamp manufacturers in this country in the form of tungstic acid, a powder and oxide.

Tungstic acid may be secured by finely grinding wolframite, heating same with hydrochloric acid, which disrupts the tungstate of iron and manganese, forming an oxide of tungsten, and chlorides of iron and manganese which are soluble. The oxide of tungsten and chloride of iron and manganese are washed thoroughly by decantation, that is, by letting it settle and pouring off the liquids. This should be done at least a dozen times. By such a procedure we secure oxide of tungsten and a few minor impurities. This precipitate is dissolved in ammonia, forming ammonium-tungstate, which is filtered free from most of the impurities.

The ammonium-tungstate which has passed through the filter is heated, the ammonia and water evaporating, leaving ammonium-tungstate, which is boiled after nitric acid has been added to it. The ammonium-tungstate, after it has been thoroughly washed with water to entirely eliminate all traces of nitric acid, becomes tungstic acid practically free from other compounds.

The First to Experiment.—Dr. Auer Von Welsbach, who more than twenty years ago brought out the gas mantle bearing his name, commenced previous to 1898 to experiment with osmium for the purpose of employing it as a lamp filament, because of the extremely high temperature to which it could be subjected without vaporizing or losing solidity. The fact

became apparent, however, that the scarcity of this article would probably make it impracticable for commercial purposes. Tungsten was therefore substituted, as it could be handled on about the same lines, and the results already secured with osmium would be of great value. At this time Drs. Just and Hanaman, working in conjunction, and Dr. Kuzel also started to experiment with tungsten as an illuminant.

Therefore, several years ago at least three sets of men, working along different lines, were endeavoring to bring out tungsten lamps.

Principal Methods of Manufacturing Tungsten Filaments.—We will take this subject up briefly and in a general way, it being unnecessary to go into details. The chief object is to show that the filament, like that of carbon, is squirted and not drawn from metal.

The Auer process consists of taking tungstic acid, driving practically all of the oxygen from it, bringing it into a state of metallic tungsten, which is mixed with a binder and squirted through delicate diamond dies, into threads.

Drs. Just and Hanaman use the substitution process, which up to a certain point is greatly similar to that employed in making the regular cellulose filament. Practically no change in construction occurs until the treating stage is reached. Then a gas of tungstic compound is used, instead of hydrocarbons.

The Kuzel, or colloid process, consists of treating metallic tungsten with strong boiling acid and alkali, alternately, washing it intermittently with water until converted into a colloid. The colloid is then precipitated, the liquid is drawn off and the residue, consisting of a gelatinous mass, is squirted. Another method of securing colloidal tungsten is to take two tungsten electrodes, place them under water, and allow an electric current to pass from one to the other. Small particles of tungsten are disrupted from the electrodes, passing into the water, forming colloidal tungsten.

Any of the three above methods will result in producing fairly pure tungsten. There is, however, more work to be done, and it is believed that all the parties mentioned herein pursue nearly the same course from this point of manufacture.

The filament having been squirted, it is dried in an oven, after which it is placed in an electric furnace operated at about 2000° C. This readily removes the more volatile parts. It is

then taken out of the furnace, and an electric current is passed through it while it is occupying an atmosphere of inert gas. The result is the production of a thread composed of practically pure tungsten.

Mounting Tungsten Filaments.—The method of mounting a tungsten filament differs from that employed with a carbon filament. The platinum tips of the leading-in wires which generally protrude from the stem are entirely sealed therein and are connected to copper wires which extend through the stem into the lamp and are electrically welded to two legs of the filaments.

The filaments in the lamp are supported by anchors attached to a glass tree which is firmly connected to the stem (Fig. 15).

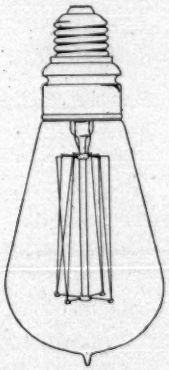


FIG. 15.

PERFORMANCE OF CARBON, TANTALUM, AND TUNGSTEN LAMPS.

From the standpoint of current, candlepower, total watts, and w. p. c., tantalum, tungsten, and metallized carbon filament lamps are less susceptible to changes in electrical pressure than regular carbon lamps. The resistance of the metal and metallized filament increases, whereas that of the regular carbon filament usually decreases with a rise in voltage.

Following will be found tables showing the comparative results upon carbon, gem, tantalum, and tungsten lamps, when they are operated at from 90 to 110 per cent. of their normal voltage:

CHANGE OF RESISTANCE WITH CHANGE OF VOLTAGE

Percentage of voltage to that of normal	Percentage of resistance to that at normal voltage			
	Carbon	Gem	Tantalum	Tungsten
90%	100.16%	98 %	97 %	96 %
95	100.08	98.7	98.5	98
100 (Normal)	100	100	100	100
105	99.91	100.7	101	102
110	99.81	101.6	102.5	104

CHANGE OF CURRENT WITH CHANGE OF VOLTAGE

Percentage of voltage to that of normal	Percentage of current to that at normal voltage			
	Carbon	Gem	Tantalum	Tungsten
90%	90 %	91 %	93 %	93.5%
95	95	96.3	97	97
100 (Normal)	100	100	100	100
105	105	104	103.5	103
110	110	108.25	107	106

VARIATION OF C. P. COMPARED TO VARIATION OF VOLTAGE

Percentage of voltage to that of normal	Percentage of candlepower to that at normal voltage			
	Carbon	Gem	Tantalum	Tungsten
90%	56 %	59.5%	64 %	67 %
95	75	77	80.5	82
100 (Normal)	100	100	100	100
105	131	128.5	123	119
110	168	162	148	141

PERCENTAGE OF CHANGE IN TOTAL WATTS COMPARED TO PERCENTAGE OF CHANGE IN VOLTAGE

Percentage of voltage to that of normal	Percentage of total watts to that at normal			
	Carbon	Gem	Tantalum	Tungsten
90%	81 %	82 %	83.5%	84 %
95	90	91.5	92	92
100 (Normal)	100	100	100	100
105	110.5	109.4	109	108
110	121.5	120.3	117.5	117

WATTS PER CANDLE OF LAMPS

Percentage of voltage to that of normal	Watts per mean horizontal candlepower			
	Carbon	Gem	Tantalum	Tungsten
90%	4.5	3.4	2.73	1.57
95	3.73	3	2.39	1.4
100 (Normal)	3.1	2.5	2.1	1.25
105	2.61	2.19	1.86	1.13
110	2.23	1.85	1.66	1.03

Watts per candle of lamps operated at 90 to 110 per cent. of normal voltage when the m. h. c. p. specific efficiency is: carbon 3.1; gem, 2.5; tantalum, 2.1; and tungsten, 1.25. See table.

In glancing over the tables given in this article, it will be seen that with the exception of resistance, the minimum and maximum points reached in performance when the e. m. f. changes are nearer to that of normal with metal and metallized filament lamps than with those having regular carbon filaments. Whereas, at 90 per cent. of normal voltage, a carbon lamp's resistance is 100.16 per cent. of that secured at normal voltage, that of the gem is 98 per cent., that of the tantalum is 97 per cent., and that of the tungsten is 96 per cent. At 110 per cent. of normal voltage the resistance to that at normal is 99.81 per cent. with a carbon, 101.6 per cent. with a gem, 102.5 per cent. with a tantalum, and 104 per cent. with tungsten lamp.

On account of the different characteristics of the resistance of the carbon, gem, tantalum, and tungsten lamps, their current is naturally affected in such a way, that at 90 per cent. of normal voltage it is reduced 10 per cent. with carbon lamps, 9 per cent. with gem lamps, 7 per cent. with tantalum lamps, and 6½ per cent. with tungsten lamps; and at 110 per cent. of normal voltage, the current of the carbon lamp is increased 10 per cent., of the gem 8.25 per cent., of the tantalum 7 per cent., and of the tungsten 6 per cent.

The resistance of tungsten, tantalum, and gem lamps, being less than that of regular carbon lamps, when operated at a voltage lower than normal, causes their current, as has been shown, to be higher respectively, and their candlepower must necessarily be greater. The carbon lamp gives 56 per cent., the gem 59.5 per cent., the tantalum 64 per cent., and the tungsten 67 per cent. of its rated candlepower, when operated at 90 per cent. of normal voltage, and 168 per cent., 162 per cent., 148 per cent., and 141 per cent. candlepower, respectively, when run at 110 per cent. of correct voltage. This shows that the light delivered by metal and metallized lamps is much less affected than that from regular cellulose filament lamps, by variation of voltage, a fact which has already been mentioned. It is a matter, however, which cannot be brought out too strongly. Therefore, let us once more refer to the table showing variation of candlepower compared to variation of voltage, and note that a

drop of 5 per cent. from normal voltage causes a reduction of 25 per cent. in the illumination received from carbon, 23 per cent. in that received from gem, 19½ per cent. in that received from tantalum, and 18 per cent. in that received from tungsten lamps. A rise of the same percentage above normal, causes an addition in candlepower of 31 per cent. with regular carbon, 28.5 per cent. with gem, 23 per cent. with tantalum, and 19 per cent. with tungsten lamps.

The increase in total watts is less with metal and metallized filament lamps than with regular carbon filament lamps, operated above voltage.

The w. p. c. do not vary as much with tantalum, tungsten, and gem lamps as they do with carbon, when the voltage is changeable. Not only are the metal and metallized filament illuminants far more efficient, but their percentage of change in w. p. c. is much less than that of carbon lamps, when run at a fluctuating voltage. When the electrical pressure is unsteady the performance of both the metal filament lamps mentioned herein is certainly most gratifying. The nearer the results obtained at varying voltage comes to that secured at normal, the more the troubles will be diminished of the parties generating and using current for lighting. With every recent development of a new lamp, a marked improvement has taken place in this respect.

Rating of Lamps.—The majority of carbon lamps are designated according to their mean intensity of light in a horizontal direction. Gem, tantalum, and tungsten lamps are rated by their lamp wattage. The valuing of lamps by the average of only a portion of their luminous flux is misleading, unless it is simply the illumination produced thereby which is being considered. In this event, the necessary light may ofttimes be strengthened by the use of reflectors, and the efficiency should be based upon the results obtained from the lamp operated in conjunction with its accessory. As the approximate total wattage of a lamp is always known, and as the effective candlepower of a lamp is often unknown to lamp manufacturers, because of their being unaware of the reflector which will be used in conjunction with the illuminant, it is easy to see why a change in rating has taken place.

Efficiency.—Rated according to their mean horizontal candlepower, the English parliamentary candle being used as a unit,

Designation		1	Carbon				Gem						Tantalum				Meridian Tungsten		Regular Tungsten			
													Direct		25 ~ Alter'g							
C. P.		2	16	16	22	32	16	20	32	40	50	75	100	20	40	20	40	32	48	20	32	48	80
Nominal W. P. C.		3	3.1	3.5	3.1	3.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0	1.25	1.25	1.25	1.25	1.25	1.25
Actual W. P. C.		4	3.1	3.5	3.1	3.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0	1.25	1.25	1.25	1.25	1.25	1.25
Total Watts		5	49.6	56	99.2	114.2	40	50	80	100	125	187.5	250	40	80	40	80	40	60	25	40	60	100
Hours Useful Life		6	450	330	430	900	450	450	450	460	450	450	450	800	800	450	600	800	800	800	800	800	800
K.W.H. Cons. dur. Useful Life		7	22.3	18.5	42.6	102.7	18.0	22.5	36 0	46.0	56.3	84.4	112.5	32	64.	18.	48.	22.	48.	20	32.	48.	80.
Cost of Lamp		8	.20	.20	.30	.30	.25	.25	.35	.35	.45	.65	.80	.50	.85	.50	.85	1.50	1.75	0 85	1.10	1.40	1.75
Cost of Renewals per 1000 Hrs.		9	.444	.241	.698	.333	.556	.556	.778	.737	1.00	1.444	1.778	.625	1.062	1.111	1.416	1.875	2.188	1.063	1.375	1.75	2.188
Cost of Power per Kilowatt Hour	.0060	10	.692	.521	1.194	.904	.756	.806	1.178	1.237	1.625	2.382	3.028	.825	1.463	1.311	1.816	2.075	2.488	1.188	1.575	2.05	2 688
	.0075	11	.816	.661	1.442	1.186	.856	.931	1.378	1.487	1.937	2.850	3.653	.925	1.663	1.411	2.016	2.175	2.638	1.251	1.675	2.20	2.938
	.0100	12,	.940	.801	1.690	1.475	.956	1.056	1.578	1.737	2.250	3.319	4.278	1.025	1.863	1.511	2.216	2.275	2.788	1.313	1.775	2.35	3.188
	.0125	13	1.064	.941	1.938	1.760	1.056	1.181	1.778	1.987	2.562	3.788	4.900	1.125	2.063	1.611	2.416	2.370	2.938	1.376	1.875	2.50	3.438
	.0150	14	1.188	1.081	2.186	2.046	1.156	1.306	1.978	2.237	2.875	4.257	5.529	1.225	2.263	1.713	2.616	2.475	3.088	1.438	1.975	2.65	3.688
	.0175	15	1.312	1.221	2.434	2.331	1.256	1.431	2.178	2.487	3.187	4.725	6.153	1.325	2.463	1.811	2.816	2.575	3.238	1.501	2.075	2.80	3.938
	.0200	16	1.436	1.361	2.682	2.617	1.356	1.556	2.378	2.737	3.500	5.194	6.778	1.425	2.663	1.911	3.016	2.675	3.388	1.536	2.175	2.95	4.188
	.0225	17	1.560	1.501	2.930	2.902	1.456	1.681	2.578	2.987	3.812	5.663	7.403	1.525	2.863	2.011	3.216	2.775	3.538	1.626	2.275	3.10	4.438
	.0250	18	1.684	1.641	3.178	3.188	1.556	1.806	2.778	3.237	4.125	6.132	8.029	1.625	3.063	2.111	3.416	2.875	3.689	1.688	2.376	3.25	4.688
	.0275	19	1.808	1.781	3.426	3.473	1.656	1.931	2.978	3.487	4.437	6.600	8.653	1.725	3.263	2.211	3.616	2.975	3.838	1.751	2.475	3.40	4.938
	.0300	20	1.932	1.921	3.674	3.759	1.756	2.056	3.178	3.737	4.750	7.069	9.278	1.825	3.463	2.311	3.816	3.075	3.988	1.813	2.576	3.55	5.188
	.0325	21	2.056	2.061	3.922	4.044	1.856	2.181	3.378	3.987	5.062	7.538	9.903	1.925	3.663	2.411	4.016	3.175	4.138	1.876	2.675	3.70	5.438
	.0350	22	2.180	2.201	4.170	4.330	1.956	2.306	3.578	4.237	5.375	8.007	10.529	2.025	3.863	2.511	4.216	3.275	4.288	1.939	2.775	3.85	5.688
	.0375	23	2.304	2.341	4.418	4.615	2.056	2.431	3.778	4.487	5.687	8.475	11.153	2.125	4.063	2.611	4.416	3.375	4.438	2.001	2.875	4.00	5.938
	.0400	24	2.428	2.481	4.666	4.901	2.156	2.556	3.978	4.737	6.000	8.944	11.778	2.225	4.263	2.711	4.616	3.475	4.588	2.063	2.975	4.15	6 188
	.0425	25	2.552	2.621	4.914	5.186	2 256	2 681	4.178	4.987	6.312	9.413	12 403	2.325	4.463	2 811	4.816	3 575	4.738	2.126	3 075	4.30	6.438
	.0450	26	2.676	2.761	5.162	5.472	2.356	2.806	4.378	5.237	6.625	9.882	13.028	2.425	4.663	2.911	5.016	3.675	4.888	2.188	3.176	4.45	6.688
	.0475	27	2.800	2.901	5.410	5.757	2.456	2.931	4.578	5.487	6.937	10.350	13.653	2.525	4.863	3.011	5.216	3.775	5.038	2.251	3.275	4.60	6.938
	.0500	28	2.924	3.041	5.658	6.043	2.556	3.056	4.778	5.737	7.250	10.819	14.278	2.625	5.063	3.111	5.416	3.875	5.188	2.313	3.375	4.75	7.188
	.0525	29	3.172	3.201	6.156	6.614	2.756	3.306	5.178	6.237	7.875	11.757	15.528	2.825	5.463	3.311	5.816	4.075	5.488	2.438	3.575	5.05	7.688
	.0600	30	3.420	3.601	6.650	7.185	2.956	3.556	5.578	6.737	8.500	12.694	16.778	3.025	5.863	3.511	6.216	4.275	5.788	2.563	3.775	5.35	8 188
	.0650	31	3.668	3.881	7.146	7.756	3.156	3.806	5.978	7.237	9.125	13.632	18.028	3.225	6.263	3.711	6.616	4.475	6.088	2.688	3.975	5.65	8.688
	.0700	32	3.916	4.161	7.642	8.327	3.356	4.056	6.378	7.737	9.750	14.569	19.278	3.425	6.663	3.911	7.016	4.675	6.388	2.813	4.175	5.95	9.188
	.0750	33	4.164	4.441	8.138	8.898	3.556	4.306	6.778	8.237	10.375	15.507	20.528	3.625	7.063	4.111	7.416	4.875	6.688	2.938	4.376	6.25	9.688
	.0800	34	4.412	4.721	8.634	9.469	3.756	4.556	7.178	8.737	11.000	16.444	21.778	3.825	7.463	4.311	7.816	5.075	6.988	3.063	4.575	6.55	10.188
	.0850	35	4.660	5.001	9.130	10.040	3.956	4.806	7.578	9.237	11.625	17.382	23.028	4.025	7.863	4.511	8.216	5.275	7.288	3.188	4.775	6.85	10.688
	.0900	36	4.908	5.281	9.626	10.611	4.156	5.056	7.978	9.737	12.250	18.319	24.278	4.225	8.263	4.711	8.616	5.475	7.588	3.313	4.975	7.15	11.188
	.0950	37	5.156	5.561	10.122	11.182	4.356	5.306	8.378	10.237	12.875	19.257	25.528	4.425	8.663	4.911	9.016	5.675	7.888	3.438	5.175	7.45	11.688
	.1000	38	5.404	5.841	10.618	11.753	4.556	5.556	8.778	10.737	13.500	20.194	26.778	4.625	9.063	5.111	9.416	5.875	8.188	3.563	5.375	7.75	12.188
	.1050	39	5.652	6.121	11.114	12.324	4.756	5.806	9.178	11.237	14.125	21.132	28.028	4.825	9.463	5.311	9.816	6.075	8.488	3.688	5.575	8.05	12.688
	.1100	40	5.900	6.401	11.610	12.895	4.956	6.056	9.578	11.737	14.750	22.069	29.278	5.025	9.863	5.511	10.216	6.275	8.788	3.813	5.775	8.35	13.188
	.1150	41	6.148	6.681	12.106	13.466	5.156	6.306	9.978	12.237	15.375	23.007	30.528	5.225	10.263	5.711	10.616	6.475	9.088	3.938	5.975	8.65	13.688
	.1200	42	6.396	6.961	12.602	14.037	5.356	6.556	10.378	12.737	16.000	23.944	31.778	5.425	10.663	5.911	11.016	6.675	9.388	4.063	6.175	8.95	14.188
	.1250	43	6.644	7.241	13.098	14.608	5.556	6.806	10.778	13.237	16.625	24.882	33.028	5.625	11.063	6.111	11.416	6.875	9.688	4.188	6.375	9.25	14.688
For each one cent difference in cost of Lamp add or subtract		44	.0222	.0120	.0232	.0111	.0222	.0222	.0222	.0217	.0222	.0222	.0222	.0125	.0125	.0222	.0166	.0125	.0125	.0125	.0125	.0125	.0125
Cost of Renewals per 1000 K W H		45	$8.95	$4.31	$7.04	$2.92	$12 39	$11.11	$9.72	$7 37	$8 00	$7.69	$7 12	$15 62	$13.29	$27.78	$17 70	$46 87	$36.46	$42.50	$34.37	$29.17	$21.87

Table of Combined Cost of Power and Lamp Renewals per 1000 Hours

the highest commercial efficiency of carbon lamps of 8 c. p. and over is 3.1 w. p. c. with a useful life of approximately 450 hours; of a gem lamp, 2.5 w. p. c. with equal useful life; of a tantalum lamp, 2 w. p. c. with a useful life of 800 hours on d. c., uncertain on a. c.; of a tungsten lamp, 1.25 w. p. c. with a life of 1000 hours.

Although the operating temperature of the tungsten filament is higher than that of any of the other illuminants mentioned herein, the lamp itself, while in service, is much cooler than the carbon, gem, or tantalum lamp.

Intrinsic Brilliancy of Lamp Filaments.—The candlepower per sq. inch of the filaments of carbon 3.1 w. p. c., gem 2.5 w. p. c., tantalum 2 w. p. c., and tungsten 1.25 w. p. c. lamps is 480, 625, 750, and 1000 respectively.

Quality of Light.—The light of tungsten lamps more closely approaches daylight than that of other illuminants. It naturally follows that tungsten lamps cause colors to retain more nearly their true values than any other artificial light source.

I wish to thank Mr. Frank M. Dorsey, chemist, for assistance in the preparation of this paper, and the Shelby Tungsten Lamp Works for the use of the accompanying table.

SEMIPRECIOUS STONES.

THE chief centre for the manipulation of semiprecious stones in Germany is in the Rhine Province.

Both at Oberstein and Idar an important industry has been created, which had its inception in the cutting and dyeing of native agate, the chief deposits of which are now exhausted. At present imported stones are handled chiefly, these coming principally from England and South America. Although agate only was dressed and colored in the early years of this industry, at present all classes of stones are prepared for market. In this, however, the art consists not only in forming the rough stone, but in giving it color as well. It was first learned that the natural color of agate could be changed by firing, and then that by warming the dressed stones in a solution of sugar or honey, and coating them with various concentrated acids which carbonize the sugar, a color was imparted to the more porous strata, while in the case of agate the impenetrable crystalline strata appeared whiter than before. [Consular Report.]

MECHANICAL AND ENGINEERING SECTION

(*Stated meeting held Thursday, December* 3, 1908.)

LIQUID-EXTRACTING INDUSTRIES AND THE DEVELOPMENT OF PRESSES EMPLOYED THEREIN.

BY
HOMER A. HERR.

THE art of liquid extracting, in its broad sense, embraces every industry where solids and liquids of whatever class or nature present-day commercialism requires shall be separated.

The paint used in beautifying our homes and preserving our structures from the hand of decay; the condiments that feed the King, the Epicurean and the Plebe; the wines, which are alike sustaining and degrading in their use and abuse respectively; the paper which is so important an element in modern life, reflecting and transmitting the intellectual activities of the world's thinkers and doers; the sweetmeats, which, regardless of their abuse, are indispensable to our life in its spring, summer, autumn and winter; the glue which enters into the manufacture of myriads of domestic articles of necessity; the fertilizer which enriches the soil that nature may give a bounteous yield to the seeds it nourishes and the landscape may be the more beautiful in its carpet of velvet and green;—all would be practically unattainable without some form of liquid extracting. These are, however, but a few of the labors accomplished by the art of the liquid extractor.

It is manifestly evident that an industry that is so co-related with our very existence and almost co-extensive with the industrial activity of the period, when embracing its many branches, is of vast human interest, of great economic moment, of large financial importance and engagement.

Before discussing the industries effected by the present methods of liquid extracting or of the means employed in former and older days, it appeals to me as a fundamentally desirable

introduction to this subject, elementary though it be, to briefly refer to the anatomical relation between liquids and their co-related solids. While it would be aside from my subject to enter to any extent into the science of vital phenomena, yet cell life in its beautiful theories and interesting facts explains the primary and physical relation between solids or the residuum of commerce and the liquids, or the oil and juice of our marts.

The literal meaning of the word cell is a hut, a cave or a small room, and every room must have a wall else no room could exist, no cell be possible.

A cell, therefore, is the fundamental form of all animal and vegetable organization into which all organized tissue is resolved.

In Nature's great design there are many classes of cells, but so far as cell life has to do with this subject it concerns the fat cells in animal life and the liquid-containing cells in vegetable life, regardless of the character of the liquid therein contained.

It will be understood that according to the cell theory the bodies of all animals and plants consist, therefore, of either a cell or a number of cells, and their products, and a cell will multiply itself by a division of its contents and the secretion of a wall about and around each portion. These capsulated elemental forms of structure or tissue contain within their walls the liquids that it is the problem of the liquid extractor to separate from the solid substance forming the wall itself. These cells are of microscopic size, countless millions in number and of infinite variety of form.

Now, just as immutable as are the laws which govern the development and formation of these cells or crystals, so fixed and unchangeable are the conditions, so immutable are the laws which must be invoked and obeyed by the liquid extractor in whatever art it is sought to separate the walls of the cells from their contained liquid, and it is evident that, inasmuch as all vegetable and animal matter is a mass of cells of substantially the same physical characteristics in like substances, they require similar treatment and similar conditions to rupture the walls and liberate the contained juices in like arts.

The evolution of an important art has its history. This history becomes interesting in proportion to the scope and human interest in the art, whether this interest is commercial, scientific or sentimental.

The art of separating liquids from solids is as old as the human race, older than history itself. The ancient Assyrians had their wine press; and who can tell but that the lost arts of the ancient Egyptians may have included in their sepulchre some brilliant mechanical scheme employed in that early day to provide wine and drink for the feasts of the Pharaohs.

On the liquid extracting of the early periods, however, I will not dwell, but it is doubtful if any of the great technical industries have shown so little of a steady evolutionary progress as have the liquid-extracting industries in one hundred years. The methods and means employed to-day are almost the same that were employed one hundred years ago.

The law prescribes the amount of liquid, under the term "moisture," which may remain in solids and the solids be thus sold. This amount of moisture is 8 per cent. That is to say, for every ton of material that is sold in a condition of commercial dryness the seller is entitled to pay for 174 pounds of water or liquid. Nature and the law seem to have a mutual understanding, for should a marketable product be sold with 4 per cent. of moisture it will speedily absorb an amount from the atmosphere bringing it up to the legal commercial dryness, 8 per cent. This, of course, does not apply to oils, fats or greases, but moisture in the form of water.

Water is very common, a very universal liquid. It exists everywhere and is found in every animal and vegetable entity during the chemical change we call growth or development. It therefore becomes an important compound with which the liquid extractor has to deal.

In a material having a higher percentage of moisture than 8 per cent. it will be necessary to get rid of this excess. The general art of carrying on this moisture elimination embraces many industries, employs millions of dollars of capital and thousands of laborers. Some of our ablest scientists, most skilful chemists and most accomplished and ingenious engineers are employed by or associated with the many different industries which contribute and represent the liquid-extracting industries of the nation and the world. Industries yet unborn will reap fortunes in the not distant future by association with some art that will be utilizing valuable liquid products now going to waste, industries which have for their base the refuse of our civilization, but

will prove to be some of Nature's hidden treasure chests and employ the art of the liquid extractor as the "Open Sesame" for securing the golden contents.

Let us see what the modern liquid extractor has to do.

Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.
1	20	21	532	41	1390	61	3128	81	8526
2	41	22	564	42	1442	62	3263	82	9111
3	62	23	598	43	1509	63	3405	83	9765
4	83	24	632	44	1571	64	3555	84	10500
5	105	25	667	45	1636	65	3714	85	11333
6	128	26	703	46	1704	66	3881	86	12285
7	151	27	740	47	1774	67	4061	87	13384
8	174	28	778	48	1846	68	4250	88	14666
9	198	29	818	49	1921	69	4452	89	16181
10	222	30	857	50	2000	70	4667	90	18000
11	247	31	898	51	2082	71	4896	91	20222
12	273	32	941	52	2167	72	5143	92	23000
13	299	33	985	53	2288	73	5407	93	26571
14	326	34	1030	54	2348	74	5692	94	31333
15	353	35	1077	55	2444	75	6000	95	38000
16	381	36	1125	56	2545	76	6333	96	48000
17	409	37	1174	57	2651	77	6696	97	64666
18	439	38	1226	58	2762	78	7091	98	98000
19	469	39	1279	59	2878	79	7524	99	198000
20	500	40	1333	60	3000	80	8000		

By a reference to this table it will be seen that to get one ton of dried material that originally carried 65 per cent. of moisture, it was necessary for the liquid extractor to expel 3714–174 (8 per cent.) or 3450 pounds of water or moisture. If the liquid extracted was oils by high pressure presses it is possible to reduce this percentage to as low as 6 per cent. in the residuum, which would give 3714–83 pounds or 3631 pounds oil per ton of residue oil cake, allowing it to contain 65 per cent. This residuum after attrition would absorb moisture from the atmosphere to the amount of 83 pounds or more per ton, depending on atmospheric conditions.

The limit of time at my command will not more than permit a slight sketch of the more important industries in which the liquid extractor is engaged, and after an understanding of the scope of a few of these industries and the relation that they sus-

tain to the wealth of our nation and the world, and the wasteful, rule of thumb, empirical and antiquated methods under which they are operated, by considering the present mechanical methods they employ, I propose to introduce to you a machine which reduces the entire art of the liquid extractor to an exact science, a new mechanism, *basic* and fundamental, a machine that spans a century of progress and relieves the liquid-extracting industries from the annoyance of present mechanisms and does not introduce new troubles.

Of all the varied industries forming the business of expressing liquids from solids none is of greater importance than the

VEGETABLE OILS.

These oils are in weight from 32 per cent. in the flaxseed to 70 per cent. in the castor bean of the entire seed and cover a wide and important range of industrial activity.

The peanut, olive, poppy, linseed, cottonseed, castor bean, sesame and paten nut all require substantially the same treatment for extracting of their respective oils from their respective oil cells.

This process is almost the same in all of them at the present time. Before going into a description of the mechanical means for obtaining these oils, it would seem a slight review of the more important of these industries would be of interest.

The most important industry among the vegetable oil industries is the cotton seed. Time will not permit me to dwell on the early doings in this industry, and it is of sufficient importance for us to know that it is to-day one of the most important industries of the United States. From being but a short time ago but an incubus that cotton operators did not know what to do with, it has become one of the great wealth producers of the nation.

There are grown in the United States about 13,000,000 bales of cotton annually, each bale weighing 500 pounds, which amounts to six billion, five hundred million (6,500,000,000) pounds of cotton. For every pound of cotton there are 3 pounds of seed, giving a yield of 19,500,000,000 pounds of seed, valued at about $200,000,000.

There are about 800 cotton oil mills in the United States which are engaged in crushing and pressing this mountain of seed for its oil, aside from that used for planting purposes.

It is estimated that there are 300,000 barrels of this oil used in Chicago for making oil lard, 200,000 in St. Louis and Kansas City, and Holland uses 250,000 barrels annually for olive oil. There is scarcely a restaurant in London, Paris or Berlin that does not use cotton oil on its tables under the name salad oil for the old Lucca product.

The linseed oil industry is also an industry of large proportions. The treatment of the seed of the flax plant from which linseed oil is obtained is the same the cotton seed. This is likewise true of the castor bean and other seeds I need not name.

The process of treating seeds for their oils broadly is: first, perfect trituration, then heating and then pressing while hot.

THE FISH OIL INDUSTRY.

A century ago it was part of the duties of the farmers along the Atlantic coast to devote some weeks in each year to catching menhaden fish (a species of the herring family) for fertilizer.

Finally they discovered that these fish were rich in oil, which they obtained and used for painting, leather dressing and other purposes. The following is the manner in which they would get the oil: They would take a few hogsheads and partly fill them with fish and water, placing boards with stones on them on the fish. The fish would disintegrate by putrefaction and the oil would float to the surface, after which they would skim it off. It would take several weeks to treat one hogshead of fish.

This method was succeeded by providing kettles in which the fish were boiled to facilitate the breaking of the oil cells and then putting the boiled fish in the casks. In 1830 this became an industry of some importance.

In 1841 the first steam cooker was built at Portsmouth, R. I. In 1850 Daniel Wells built the first fish oil factory on Shelter Island. He handled about 3,000,000 fish per annum.

The first press was built by Charles Tuthill, at Wells's factory, in 1856. This worked so satisfactorily that soon factories commenced to develop rapidly. In 1858 hydraulic presses were first used in this industry.

In 1876 floating factories were introduced. These consisted of presses, cooking tanks and boilers mounted on steamers, sail vessels or scows, and they would follow the movements of the fish.

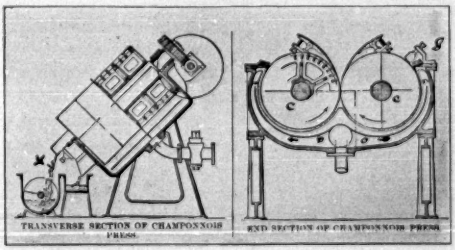
The fish oil business continued to expand until it reached

high water-mark in 1884, when 858,592,691 fish were caught, yielding about 4,000,000 gallons of fish oil and about 80,000 tons of tankage.

The average catch of fish in the past 30 years was about 500,000,000 annually. In 1902 about 900,000,000 fish were caught.

Among the many different methods for extracting oil from fish was the process employing fumes of benzin, naphtha and also bisulphide of carbon. When these are brought in contact with the fish in airtight chambers they absorb the oil, which is subsequently recovered by evaporation. This method has been abandoned, not only for fish oil but for nearly all purposes for oil extraction.

FIG. 1.



In 1858 the Ocean Oil & Guano Co. of Southold, N. Y., used a steam cooker similar to the continuous cookers now in use.

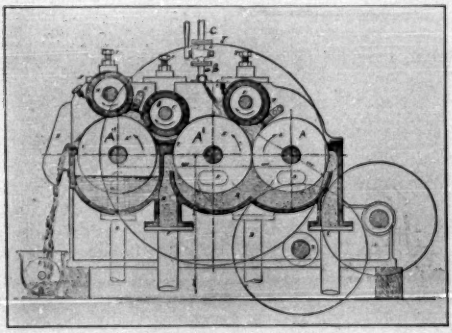
This cooker consists of a steel shell 20 ft. to 30 ft. long. The material is carried along the barrel of the cooker and is broken up by radial arms carried by the hollow shaft which is charged with steam at 80 pounds pressure; from the cooker it goes to the press. It is good practice in this art to allow the fish to remain in a vessel for a few hours after cooking to permit the drawing therefrom of a good per cent. of the oil (as much as 60 per cent. of the oil can be obtained in this way), and then finish the extraction of the oil by pressure.

Screw presses of all classes for fish oil extraction are not efficient. They do not effect a satisfactory extraction of the oil and the fish tankage is consequently of less value, as oil is not a fertilizer.

Under ordinary conditions about 8 per cent. of oil remains in the fish, but with such conditions as obtain in a hydraulic press which I will presently describe, this can be reduced to 5 per cent. if not less.

It is probable that no application of the mechanical powers can boast of such antiquity as the press. The form in which it was first used is lost in antiquity and it is indeed doubtful if any of the arts has shown so little progress as the press, broadly considered, by which the wine and oil, so early recorded among the wealth of nations, were extracted.

FIG. 2.



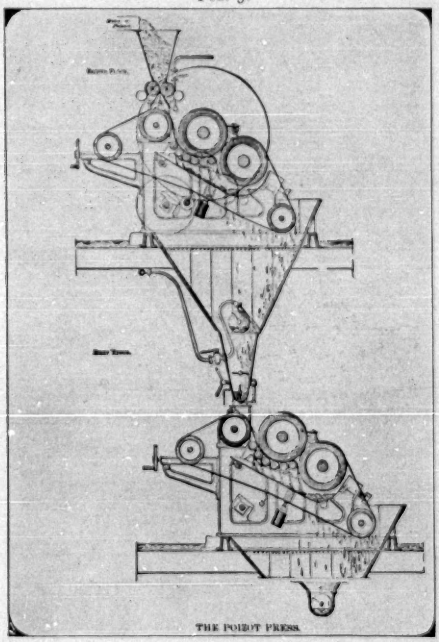
Lebee's press.

The crushing and pressing of vegetable seeds for oil was first introduced into England in the eighteenth century. The Dutch had long since expressed oil from flaxseed by means of plates pressed together by wedges, which were operated by falling weights in the manner of stamp mills.

Ofttimes an artist becomes an historian unwittingly and intuitively and thus fills a gap in the transmission of useful and accurate knowledge to the generations that succeed him. Where the spirit of a period is intensely practical and the conditions of an industry are primitive and empirical, literature of a technical character touching such industry does not exist; thus sometimes does the painter or the poet become the recorder of industrial evolution or mechanical progress.

David Teniers, the celebrated artist, painted a picture in 1623 of an oil mill as above described. This picture is now in possession of Earl Cowper of England and gives an accurate view of one of these old and early mills. Some of these mills still exist in Hull and in Holland. The principle embodied in these early mills is a very excellent one—the wedge.

FIG. 3.



THE POIDT PRESS.

Abrasive action in a liquid-extracting press destroys in many materials the value of the residuum. This is particularly true of substances rich in protein, such as brewers' grains, beet sugar pulp, distillers' slops; in fact of all substances where the material of value is the solids and not the liquids and in many substances where both the solids and liquids are valuable.

Where an abrasive action is employed in the separation of the liquids from the solids, the oil or the liquid becomes heavily impregnated with residuum, and if it is desirable to separate these solids or to purify these liquids, it is a matter of additional expense.

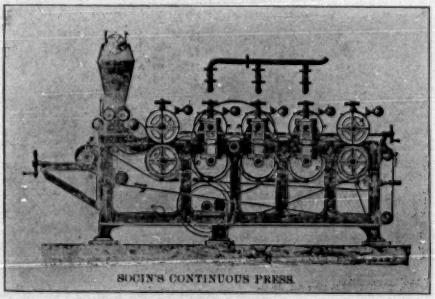
Liquid-extracting machines of to-day are of four general classes:

1. The roller press, including all machines which have rotating cylinders and metallic belts.

2. Screw machines, including all machines which have a screw action or a twisting of the mass of material under treatment.

3. Centrifugal machines, or machines having a hollow perforated rotary cylinder in which a saturated substance can be placed; a rapid rotation of the cylinder forces the fluid through the holes by radial or centrifugal action.

FIG. 4.



SOCIN'S CONTINUOUS PRESS.

4. The hydraulic press, or where hydraulic pressure is employed under the principle of relative velocities.

There are many modifications of the screw and roller presses that need not be considered. There are few in use and they are not practical for the purpose. We shall now consider these machines in the order stated.

First, the roller press, its merits and its weaknesses:

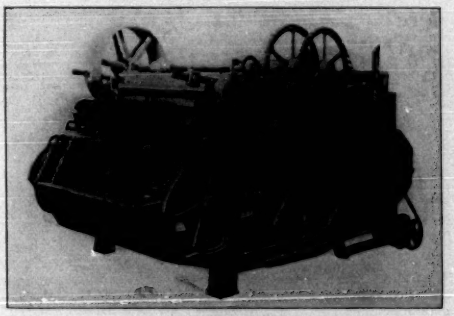
These machines may be subdivided into two distinct classes and some modifications:

Roller machines, in the manufacture of cane sugar, where the

cane is passed between ponderous rolls. Some of these machines are of such dimensions as to require 1000 horse power to operate them. They are well known and I shall not dwell further upon them except to say that they are at present extensively employed in the cane sugar industry, but I prophesy that within moderate time limit they will be succeeded by other better and more economical methods and other and more efficient machines.

The evolution of an art, the evolution of an industry, is sometimes based on knowledge, sometimes on caprice, but nearly always on tests, trials and experiment.

FIG. 5.



Louisville and Kutztown presses.

During the early years of making sugar from beets, presses were employed to extract the sugar juices from the beets direct, the juices were then treated to recover the sugars from the foreign substances therewith contained.

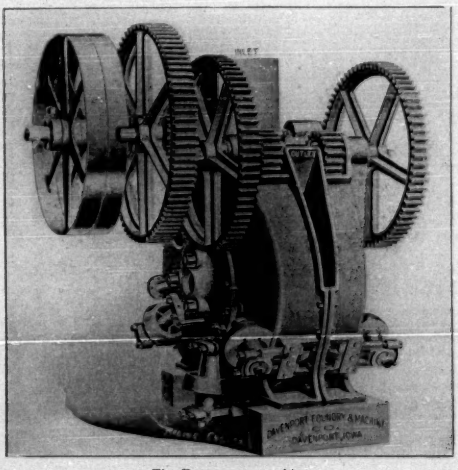
To-day beet sugars are separated from their foreign companions by the diffusion process. This process is based on the phenomenon of osmosis, which occurs between the water and the sugar juices. That is, the water enters the cellular tissues of the beets and drives out the sugar liquid. This gives a purer juice than was possible under the above primitive system of beet-sugar manufacture; and now instead of employing presses to drive the sugar liquids from their cells in the beet cossettes, the presses are employed to drive the water from these cells, after it has driven the sugar juices therefrom.

Now let us consider some of these machines briefly.

CHAMPONNOIS PRESS.

This is in fact a roller press and consists of two rollers sunk into the frame of the apparatus and revolving in opposite directions. The cylinders are covered with a spiral wrapping of triangular wire. The pulp is forced into the lower part of the press (Fig. 1) by a pump and on both sides of the open space o,o, and between the rollers. The juice passes through the spaces between

FIG. 6.



The Davenport machine.

the wire wrapping on the peripheries of the rollers and flows from the machine at X. The roller pulp is scraped from the cylinders by two blades and falls into a receptacle.

LEBEE'S PRESS.

This press (Fig. 2) was claimed to combine the advantages of the Champonnois and some others. At one time it was popular; it is not now used. The pulp is forced into the chamber at B, through the pipe C. The cylinders A,A then press the pulp which

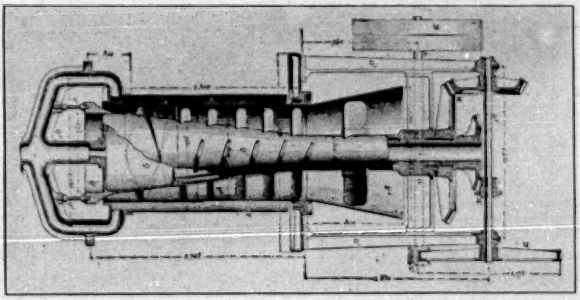
continues moving forward under the cylinders F and A′, thence between A′, 1, M and A″ and finally to exit. The juice flows from the pipes D and O to exit. Each cylinder has about 5000 spiral blades, the equivalents of the spiral wire wrappings of the Champonnois press.

POIZOT PRESS.

This press is not much used; a few are in operation in France, and thirty years ago it had some friends. They are nearly all dead, either to the world or to the machine.

It consists (Fig. 3) of a series of cylinders or rollers and an endless belt moving over and around a series of cylinders. The material passes between the cylinder and the belt. The belt being

FIG. 7.



The Bergreen screw press.

perforated forces the liquid there through. A cleaner is carried by the machine which scrapes the residuum from the large cylinders.

These machines were mounted in pairs on two floors, the lower being an exact duplicate of the upper one.

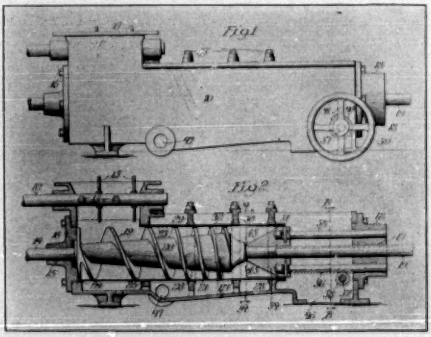
SOCIN'S PRESS.

This machine (Fig. 4) is but a modification of the Poizot. It consists of the same elements, that is, an endless perforated belt and a series of rollers. The material passes between the rollers and the belt, the pressure thereby created forcing the liquid through the perforations of the said belt.

The above roller machines embody the exact principles of all roller machines now made in this country, and in fact the present roller machines are almost exact duplicates in every element of either the Lebee, Champonnois, Poizot, Socin or Collette, just as nearly every screw machine is a resurrected DuJardin used thirty-five years ago in the beet-sugar industry in Germany and France.

The machines just described are all substantially obsolete. Occasionally they reappear in a new dress but the form is the

FIG. 8.



The Vernstein machine.

same. The new press with its ancient form takes its final rest in the scrap heap as its ancestors did before it.

LOUISVILLE AND KUTZTOWN PRESSES.

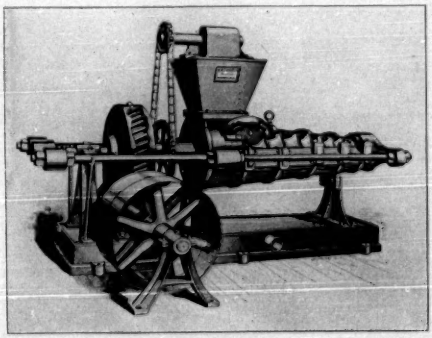
These machines (Fig. 5) are the same in all their elements as the ones I have briefly described. They consist of a series of pressing rollers, a perforated metal cloth or fabric and a cleaner, with means to actuate the parts, but they are by no means as effective a press as the Poizot, and in due course they will no doubt find the efficiency of their successors will make life burdensome.

The Davenport machine has some structural novelty as a roller press. It consists (Fig. 6) of two inclined discs, whose

axes are upwardly inclined. The upper parts of their adjacent sides are at all times wider apart than the lower and as they rotate they draw the material downward to the narrow adjacent lateral faces and force some moisture from the material thus treated.

I will not dwell on other machines of the roller class; they will appear and disappear as they have done for fifty years, but none of them can hold its market, none of them is correct in principle, and they are all on the same principle. They fail in this: the object of liquid extracting is to express liquids from

FIG. 9.



The Lafferty machine.

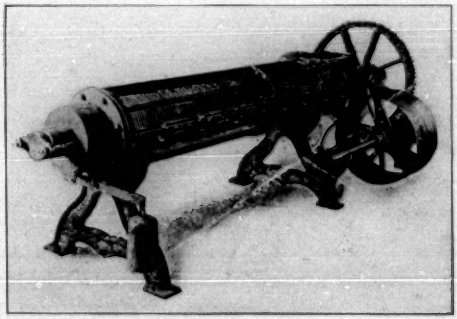
solids so that the solids may be sold on the open market on a basis of 8 per cent. moisture. To do this so that it can be made commercially profitable mechanical pressure must extract the moisture to as low a minimum as possible.

With these presses it is scarcely possible to reduce the moisture below 65 to 55 per cent. Now a material carrying 65 per cent. of moisture must have 57 per cent. of this moisture evaporated before it can be sold or before disintegration will cease chemically. This means that for every ton of material dried for the market 2650 pounds of water will have to be evaporated by a mechanical dryer, and as it requires about one pound of ordinary mine run coal to evaporate seven pounds of water under favorable con-

ditions, it follows that 2650 pounds of water in a boiler will be evaporated by 380 pounds of coal, but in a steam dryer the value of coal is impaired fully 50 per cent., therefore, when steam dryers are used 2650 pounds of water will require 760 pounds of coal, and with coal at $4.50 per ton, it will cost about $1.50 for coal to evaporate the moisture from the material as it comes from a press 65 per cent. moist for every ton of dried material.

Now we will assume that this was a wet grain material and that the product was ten ton of dried grain daily. There would be a cost for coal alone of $15 per day, a large percentage of which could be saved by an efficient press.

FIG. 1c.



The Guy and Smith machine.

But there is another and equally great loss occasioned by all these roller machines, and wherever you see such a machine in operation you will find the following to be a true condition: The action of these roller machines is harsh and abrasive, they mutilate, they rub the material they press, and this rubbing, this mutilation forces the gluten or protein away with the liquids. Dried grains treated in a roller machine have the most nutritious part carried away with the water and it cannot be avoided. It would be a profitable contract to have the waste occasioned by a roller machine saved and conserved by a means that can do so for as small a volume of material as 500 bushels daily.

SCREW MACHINES.

The principle of the screw has been employed in many slightly modified ways in presses for liquid extracting. These devices are very similar in construction. They consist of a tapered screw in a tapered chamber. The chamber is built in various ways and is usually from 8 to 12 feet long.

In beet-sugar mills the Bergreen pattern of screw press (Fig. 7) is used extensively for expressing the water from the cossettes after they come from the diffusion batteries. It consists of an iron plate cylinder P, which encloses another P^2 containing rectangular apertures and surrounded by a hopper P^3, in the interior of which revolve two superimposed truncated cones Q and Q.′ The latter of these, Q′, carries spirally arranged arms which are so arranged as to compress the slices and push them toward the bottom. On a line with this the lower cone Q revolves in an opposite direction. The slices, pressed, pass through an annular orifice whose diameter is regulated by a ring q and screw q′.

Beet-sugar pulp is about 95 per cent. moist. That is, for every ton of dried pulp you must get rid of 38,000 pounds of water, or 19 tons. These presses cannot reduce the moisture to below 80 per cent. This still leaves 8000 pounds of water to be handled by the dryer, less the legal allowance.

The pulp is valuable as a food for cattle and they thrive on it. As an idea of the great demand for an efficient machine I will give you facts as to the development of the beet-sugar industry in this country and abroad.

This industry had its birth in 1867, but slow progress was made for many years—so slow that in 1892, only sixteen years ago, but six factories were in operation and their combined output was only about 28,000,000 pounds. Now there are sixty-five factories in operation in the United States and they produce about 500,000 short tons of sugar with a value of almost $50,000,000.

The Department of Agriculture at Washington has encouraged the growth of sugar beets, and at its experimental stations is producing a very high grade of beet seed. So high is this grade of seed that tests show that they contain as high as 18.18 and sometimes 20 per cent. sugar.

There are in France 350 sugar factories. All these factories make 1,200,000 tons of sugar, using 8,700,000 tons of beets. In France they obtain about 12 per cent. sugar.

VERNSTEIN MACHINE.

Fig. 8 shows a vertical, longitudinal, and side elevation of a screw press with a conical core and spiral annular flanges with varying pitches. Fundamentally it does not differ from the beet-sugar machine of Bergreen used in the DuJardin's beet-sugar diffusion battery mills forty years ago. The taper plug in this machine, supported by rods and operated by a rack and pinion, has its equivalent and almost identical structure in the ring plug in the Bergreen machine.

LAFFERTY MACHINE.

This machine (Fig. 9) has a solid core with circumferential spiral grooves decreasing in diameter toward the discharge end. In this respect it differs from the machines described. The discharge part is substantially the same.

GUY AND SMITH MACHINE.

This machine comprises a cylinder with a core having circumferential spiral flanges with varying pitches (Fig. 10). It differs in having circumferential slots to permit the liquid to pass from the press chamber.

There are other machines made on substantially the same lines as the above. Some carry longitudinal slots to permit the discharge of the material, others have distinguishing features that differentiate their structure specifically, but specifically only. The fundamental principle and the specific, indeed, is almost the same in all these machines. In all of them the material is fed into the hopper at one end and the screw rotates slowly, about two revolutions per minute. The pitch of the thread (spiral) varies, contracting towards the discharge end of the machine. The density of the material in the chamber gradually increases as the material is forced to the end of smaller area and the liquid passes out in slightly differing ways already described.

The same weaknesses that attend the use of the roller machines are found in these screw presses. They abrade and abuse the material, but even for material for which they are suited

they are no more uniform in results than roller machines and will not expel much moisture with any degree of reliability.

CENTRIFUGAL MACHINES.

I do not propose to make more than a reference to centrifugal machines. These machines are used in sugar manufacture to separate the sugar crystals from the boiled syrups which contain them, also in other arts. In the manufacture of beet sugar we first slice the beets, then put these slices through the diffusion batteries, then reduce the juices by evaporation to get the sugar crystals by methods that need not concern us here. The syrups are now put through the centrifugal and the juices are thrown by radial action through the perforations in the wall of the centrifugal cylinder. These cylinders rotate from 800 to 1700 revolutions per minute. The perimeter should travel from five to seven miles per minute. The separating of the juices from the sugar crystals at this great speed is very complete and with first charges speedy. The rotating machine is stopped to unload the sugar remaining in the basket. There are many thousands of these machines in use. While their efficiency as extractors is far in advance of screw or roller machines, they are yet highly imperfect mechanisms and a very large fortune awaits the man who can perfect centrifugals beyond reasonable need for improvement.

In the manufacture of sugar from cane we have first the juice extraction; second, the juice clarification, usually done by a filler press; third, juice evaporation; fourth, syrup production; fifth, syrup concentration; and then sugar production finally by separating the crystals from the syrup by centrifugals. Centrifugals are also used extensively in other industries, but we can dwell on them no longer.

In the machines I have considered for liquid extracting there are inherent weaknesses, faults and objections that are co-existing with the structural principles of the machines themselves. I have directed attention to some of these faults and weaknesses. For high-pressure work these machines have been or are being abandoned. Occasionally a new press appears for low-pressure service in either the screw or roller type, but like those previously designed it lacks in efficiency and soon passes out of use.

Liquid extracting should be an exact science. We should be able to predetermine results, not guess at them. When we have a manufacturing plant that is based on an extraction of 50 per cent. moisture and our dryers are designed to handle material of that per cent. moisture, we do not want to have to treat a 65 per cent. material one hour and a 50 per cent. the next, and possibly 60 per cent. the next, but that is exactly the condition that obtains at present where screw or roller presses are employed.

THE HYDRAULIC PRESS.

The hydraulic press was invented by Joseph Bramah in 1796. This machine has been the most reliable and, indeed, the only reliable ever since, in every application where power and reliability are wanted or needed. Our subject, however, limits us to considering the hydraulic press in liquid extracting.

Hydraulic presses are based on the principle of relative velocities, the underlying principle of many machines. The power of the hydraulic press is established by the relative areas of the piston which pumps the water and the piston (called the ram of the press) which directly moves the load.

Three hundred and thirty years ago Fontana raised an obelisk in Rome with 40 capstans, worked by 960 men and 75 horses; 46 years ago Le Bas raised the Luxor obelisk at Paris with 10 capstans, worked by 480 men; 24 years ago Mr. Dixon raised Cleopatra's Needle in London with 4 hydraulic jacks and 4 men. This gives a slight idea of the power of a hydraulic machine.

Water is almost incompressible but not absolutely. This diminution of volume for water is $^1/_{20,000}$ of its total bulk for a change of pressure of one atmosphere or one-seventieth ($^1/_{70}$) of its volume for a pressure such as we find in hydraulic presses.

A screw will sometimes give 30 per cent. of the energy put into it. Ofttimes it will not give more than 15 per cent. A differential pulley block may give 40 per cent. A hydraulic press will give 90 per cent. This gives us a relative idea of the value of a hydraulic press as compared with the screw, based on tests and recognized facts.

In the early employment of hydraulic presses for liquid extracting they were often operated in pairs and consisted of two stationary plungers and movable basins, having lateral and bottom perforations. The liquid was discharged from

the spout in the basin as the basin moved upward against the bottom of the plunger. This was a very expensive and slow method of getting juices and was succeeded by the press cheese of to-day. This press cheese consists of a slatted frame on which a cloth is laid; the material under pressure is placed on the cloth and folded in its four corners inwardly, the corners covering the material. The loaded frames or racks, as they are called, are then piled on top of each other for the press load and pressure is applied.

While the ability to produce a known and desired pressure is substantially the exclusive virtue of the hydraulic press, yet in its practical application to the liquid-extracting industries it has drawbacks and disadvantages. These drawbacks, these disadvantages have been on the score of economy. Nevertheless, regardless of this operating expense, it is estimated that there are over 20,000 hydraulic presses engaged in these liquid and pressing industries in the United States to-day. All other presses combined have but a fraction of this number. These drawbacks, weaknesses and disadvantages have led to considerable activity among inventors, and we will consider a few.

It is the practice in high-pressure liquid-extracting vegetable oil work to first heat the meal, after grinding and thoroughly triturating the seed, by heaters specially designed for this purpose.

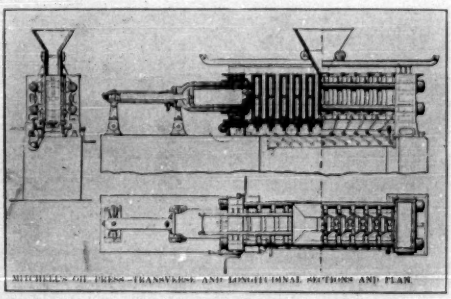
The meal is then formed into cakes and placed in the press, one on top of the other, as already described. All this involves labor. In low-pressure work, that is, in the machines where the pressure is not over 250 pounds on the material, it usually requires about three to four men to handle one press. These men load the cheeses and carry them to the press, open and close valves, and unload the press after pressing. This labor, while not skilled labor, brings the cost of operating a single low-pressure machine up to about $1500 to $2000 per annum. Where an industry has a large number of presses in service this can be reduced.

There have been many attempts made to eliminate some of this labor.

Fig. 11 shows one of these devices designed by an English inventor named Mitchell. It was the intention of this inventor to have open boxes for cheeses and mount a railroad over the boxes and move the hopper along on the railroad discharging

into the hopper. Each box carried a pipe outlet, and they are connected with a common pipe through which the oil was conducted from the machine. Another inventor some eight years ago conceived the idea of mounting twenty-four hydraulic presses on a turntable and having the turntable rotate intermittently and having its rotary movements arrested twenty-four times in a complete rotation of the turntable, and when it was arrested one of the hydraulic presses would come in line with an automatic cake former, at which time the said presses would be loaded with the cheeses of meal, after which the turntable would again start and bring another press to cake former, and so on.

FIG. 11.



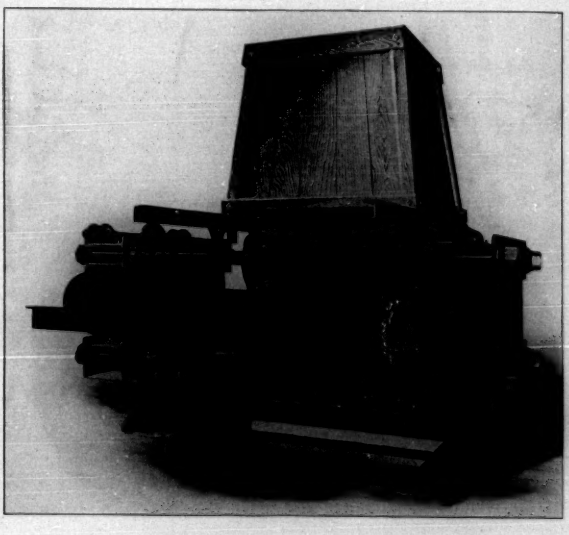
MITCHELL'S OIL PRESS—TRANSVERSE AND LONGITUDINAL SECTIONS AND PLAN.

In his specification this inventor uses the following language: "In the present invention for several reasons, among which may be named the difficulty of conveying the formed cake from the place where it is made to the various presses of the mill and the difficulty of delivering such cakes to the various chambers of the press, I prefer notwithstanding the great weight of the presses relative to the small weight of the cake to bring the presses one by one to the cake-forming machine and to lower the press platen after lifting to full height, so that chamber after chamber shall come into position to receive the cake from the forming machine without bodily moving the latter, and to discharge the cake by a like press movement, and to this end I mount a series of hydraulic presses, say twenty-four, on a turntable which moves around on a fixed track with a step-by-step motion, one step for each press,

and provide said turntable with means for raising and lowering the presses bodily with a step-by-step movement corresponding with the distance between the cake chambers of the press."

Of course this machine was a mechanical monstrosity, and yet I am told one of our large trusts spent the sum of $250,000 building a mill with this machinery. The idea of moving 175 tons of metal to a little cake, weighing at the most not over 60

FIG. 12.



The Herr hydraulic press and compression chamber.

pounds, is indeed absurd, and yet, so desirous and so anxious are the industries who use these machines to effect economies that one of our great trusts spent the sum of one-quarter million to see if it would work.

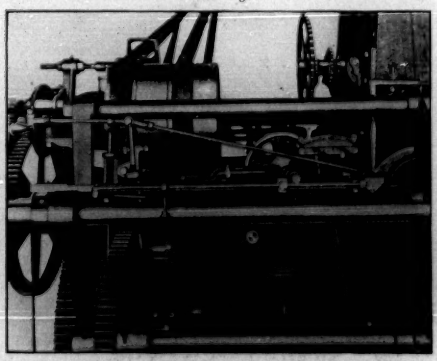
We are living in an age where industrial economies have the call. There never was a time in the march of the world's industrial progress when the conserving of Nature's treasures was

more important than it is to-day; never a time in the history of the world's industries when problems of vast economic and industrial import were getting such practical solution as they are to-day; never a time when capital was so alive and so willing to enlist in industries which have for their base valuable liquids now only partly obtained.

I now propose to describe a machine that is destined to effect a revolution in the liquid-extracting industries. It is hydraulic and automatic in its action.

In all industrial operations it is the constant endeavor to re-

FIG. 13.



Chamber regulator.

place manual labor by mechanism, and when the latter operates in an automatic and continuous manner, improvement has reached its limit, and it only remains to perfect details and possibly modify them to the end that structural simplicity results.

Screw machines and roller machines I scarcely consider seriously. They will gradually all pass off the stage, limited as is their use to-day.

While the hydraulic press gives us the power to do work, this automatic machine that I am now about to describe relieves these machines of all the objection heretofore urged against their universal use as liquid-extracting machines and obviates all their weaknesses.

The present state of development of this machine represents a century of progress. It provides a means, for all industries employing hydraulic presses for liquid extraction, of making their pressing operations entirely automatic.

The machine is self-feeding, self-cleaning, and takes care of the residuum and the extracted liquid. It applies a uniformly distributed pressure and maintains that pressure during a time limit suitable to the requirement of any kind of substance.

The uniformly distributed pressure on all parts of the material leads to high efficiency of operation and a high quality of product. The extraction of moisture is uniform and the residuum is, therefore, dried at small expense.

In addition to the higher efficiency, the predeterminable control of the moisture condition, the superior neatness and saving of labor by its automatic operation increases the production of a plant with less labor than required at present.

Fig. 12 is a general view of the hydraulic press and compression chamber, which lies, horizontally supported, upon suitable foundations.

The compression chamber is rectangular and formed of steel plates supported by braces and attached to the tension rods. The entire chamber is "knock-down" and can in a few moments be dismounted, each plate withdrawn independently or assembled as required.

Within the chamber transverse drain-trays are provided. These are covered with a fine filter fabric to suit the material under treatment. The trays are made of a special wood and conduct the liquid from the material to a collector carried by the bottom of the compression chamber.

CHAMBER REGULATOR.

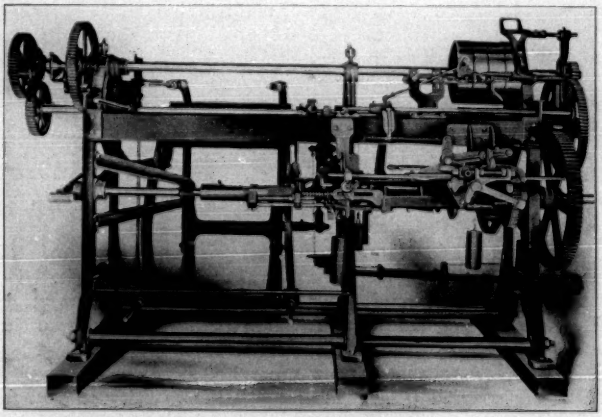
Fig. 13 shows the chamber regulator which enables the attendant to adjust the mechanism which controls the rate of feed so that the density will be uniform, the pressure uniform, the liquid extraction and the residuum uniform in the percentage of moisture extracted and retained.

The device not only insures uniformity in density of material in the chamber but also regulates the action of the chamber-cleaning mechanism providing a chamber cleared of all residuum after each pressing. These two important functions, uniform-

ity of density during pressing and complete discharge of all residuum after and between each pressing, yield a practically perfect result.

B in the figure is a clutch controlled automatically or by hand. The automatic control operates by setting an index at a point on the time scale indicating the time during which the chamber is to be kept open for filling. The same regulator controls the time

FIG. 14.



The automatic machine.

allotted to cleaning, and different materials require different times for this function.

THE AUTOMATIC MACHINE.

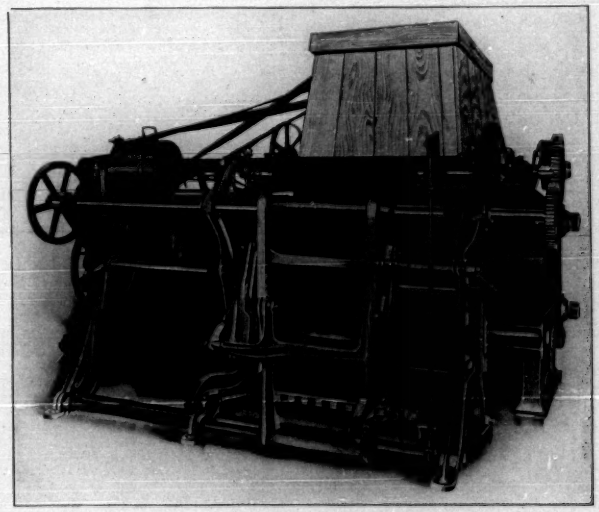
The "automatic machine," or the mechanism which operates the opening and closing of the lid of the compression chamber, the bottom of the chamber, the feeders in the hopper, the valves, and, in fact, all the kinetic parts of the mechanical organization is quite simple (Fig. 14).

It is placed alongside of the compression chamber and hopper as shown in Fig. 15 and firmly attached thereto by suitable ties. The moving parts of the compression chamber and hopper are

connected to the operating points of the machine and constrained to move in unison with them.

The motion of the hydraulic ram controls the element actuating the bottom of the compression chamber and the motion of the bottom controls the movement of the lid. The exhaust valve from the hydraulic cylinder is operated by the closing of the lid.

FIG. 15.



Automatic machine attached to press.

When the lid is closed this valve closes and the pump supplying the ram is started, forcing the platen against the material in the compression chamber.

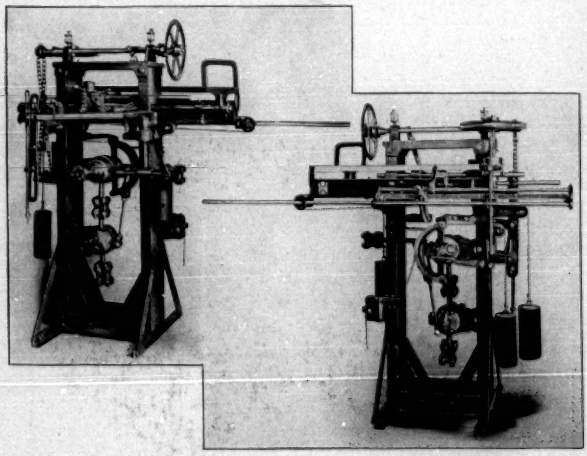
This pressure continues until the desired maximum pressure is reached as predetermined by the pressure regulator. Thereupon the pump automatically stops and the pressure held at this point for a period which varies with different materials predetermined by the time gauge.

When the time limit has expired the exhaust valve from the

hydraulic cylinder is automatically opened and the platen moves back to its initial position.

The drainage partitions within the compression chamber are also automatically separated by the backward movement of the platen and the meal cake is freed from the side thereof. The bottom of the chamber is then opened and the partitions within are cleaned automatically. The bottom is now closed and the

FIG. 16.



The time recorder and pressure sustainer.

chamber is entirely empty. The lid is opened, the chamber again filled, the lid closed, valves operated and pump started—all automatically and with precision.

THE TIME RECORDER AND PRESSURE SUSTAINER.

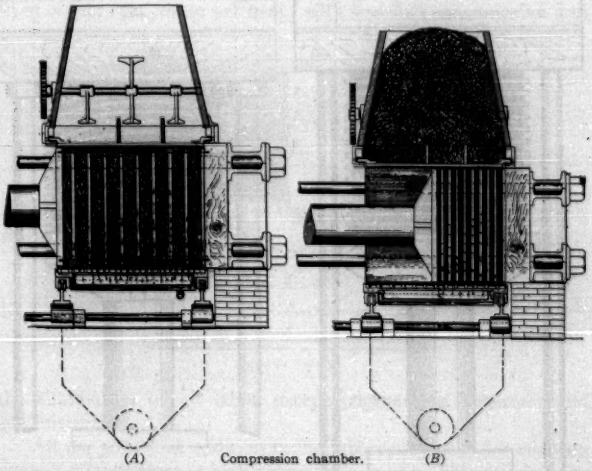
This machine carries the hydraulic high-pressure valves and controls the movement of the ram according to the following requirements:

Different materials require different pressures and a greater or less duration of the maximum pressure. The responsibility for maintaining this maximum pressure for the exact number of

minutes required devolves upon the sustainer and so precise is its action that it can be adjusted to the fraction of a minute and the pressure maintained during that period with a variation of less than 1 per cent.

To clearly understand this action, let it be assumed that the required pressure on the ram is to be 2500 pounds per square inch. When the press chamber is full, the pump starts automatically and the pressure rises until the gauge records 2500, at which moment the pump is automatically stopped. Assuming, further,

FIG. 17.



(A) Compression chamber. (B)

that it is required to maintain this pressure for ten minutes, the index of the time-gauge, Fig. 16, is set at the ten-minute mark.

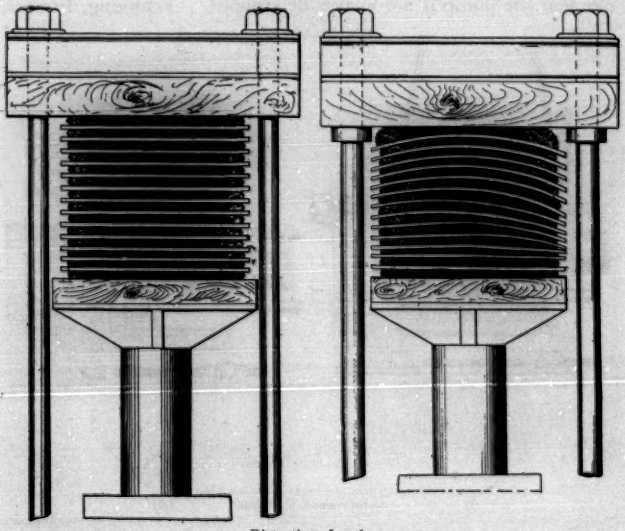
This means that the pressure will be maintained on the material for ten minutes, for it requires that time for the index to travel to the zero point of the time-gauge, in which position it trips the exhaust valve, and the pressure is instantly and automatically released.

Fig. 17(A) shows the construction of the chamber. The material is distributed over every part of it and, being contained within fixed walls, cannot diffuse itself. What little creeping

occurs is an automatic adjustment to a normal action in obedience to natural laws.

Fig. B shows the ram after the material has been subjected to the maximum pressure. Fig. A shows the chamber loaded before pressure, the even density in B, how the parallelism of the drain-racks is maintained. The distortion of these racks under the former practice is illustrated in Fig. 18. The strain cloths have

FIG. 18.



Distortion of racks.

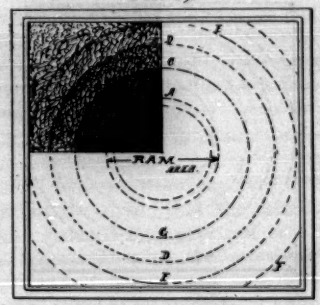
longer life by the elimination of the tearing, twisting and abrasive action upon them. They are subjected to compression stresses only, no tension as at present—a feature of great economy. Careful tests have demonstrated that, in point of efficiency, no other machine can approach the automatically controlled hydraulic press fitted with a chamber of this design. The zone of pressure is uniform and the extraction is uniform over the entire area of the chamber and, indeed, on the entire mass of material.

Fig. 19 indicates the lack of uniform density in the usual form

of low-pressure hydraulic machine. The "ram area" has an abnormally great pressure between the circles A and C which is too high and bad work is the result. Within the annular space D and C the pressure is about correct; no waste of gluten or solid nutritious matter occurs and the proper percentage of moisture is obtained. Beyond the circle D too much moisture is left in the material that should be extracted. Beyond the circle E the material creeps and tears the cloths. All these faults exist in the common practice and all are avoided by the automatic press.

With this press the daily capacity of everything is increased from 20 per cent. to 40 per cent., with less fuel consumption and

FIG. 19.



Variable density.

the elimination of all labor except engineering attention and administration.

All the power, in addition to the labor, now used in pumping against safety valves at high pressure is saved. This saving with a 12-inch ram is at least $300 per annum, with a 16-inch ram about $500, and with a 20-inch ram about $750 for each machine in daily use.

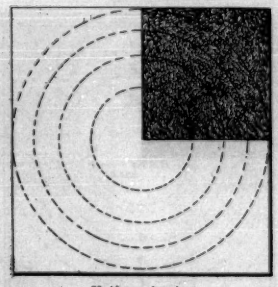
The economy in labor effected, as compared with the ordinary press, is three men for each low-pressure machine, or a minimum of $1500 per annum. Of course when a large series of machines is in use this can be reduced. With high-pressure machines it would be less.

The economy is measured by the difference between evaporating the 60 per cent. moisture in material supplied by a screw or

roller machine, which is about the best performance of either, and the 30 per cent. moisture contained in material from the automatic press. This is a difference between 3000 at 60 per cent. moisture and 857 at 30 per cent. moisture (see table), or 2143 pounds of water which must be evaporated by the dryer.

It will therefore require almost three times the dryer capacity, for instance, to dry brewers' grains passing through a roller press, that is needed for the same material from the automatic press. In the former case the most valuable part of the grain is lost and in the latter this valuable part is saved. What is true of brewers'

FIG. 20.



Uniform density.

grain is equally true of all substances. It is specifically mentioned as representative only.

The important features peculiar to the improved machine may be thus briefly summarized:

It is automatic in every particular; it produces a maximum pressure with accurate uniformity on independent press loads and on every part of the same press load; it will sustain the maximum pressure as desired without power, all power being cut off at the maximum pressure. The period for maintaining maximum pressure can be varied to suit any condition or material; it increases the capacity of the ordinary press without increase of power or labor required; the automatic control and operation of the machine makes the process comparatively independent of labor disturbances and thus relieves users from many annoyances and anxieties attending ordinary press-room conditions.

MECHANICAL DRYERS.

Dryers are employed to reduce the moisture from the material after it leaves the press to a condition of commercial dryness, or 8 per cent. Few, if any of the present presses extract moisture to 60 per cent. and it is the function of the dryer to reduce this moisture to 8 per cent., which means that the dryer must evaporate 2826 pounds of water for every ton it dries, and where a plant is producing 50 tons per day, 143,300 pounds of water must be evaporated.

Whenever the nature of the material will allow of the direct use of gases or combustion, the economy over the use of steam is very great, and in a well-designed and well-constructed apparatus the best authorities estimate that the expense will be from 40 per cent. to 60 per cent. less.

In steam there are several losses inseparable from its use:

1. Imperfect combustion by fuel under boiler.
2. Loss of heat in chimney.
3. Loss of heat by radiation in conductors leading from the boiler to dryer.

Even the use of exhaust steam involves a condition of such low temperature in the dryer that the function of drying is accomplished with reduced intensity, and as a result numerous dryers become necessary, with the attending extra cost of maintenance.

Packers' plants, garbage plants, fish-oil mills, chemical establishments, distillers' slop plants, beet mills, brewers' grain mills, sizing plants, all use low-pressure machines and dryers.

The low-pressure machines, if hydraulic, give a pressure of from 300 pounds on the ram area to 10 pounds on the perimeter of the cheese and an average extraction of approximately 46 per cent. with conditions favorable, and when the hydraulic indicator shows 3000 pounds' pressure in the cylinder the ratio of distribution of the pressure on the mass is about as 1 to 4, with one part of the mass being under the pressure indicated by 4, and 4 parts of the mass being under the pressure indicated by 1 and so on conversely at intervening ratios. Therefore, a large portion of the mass is not getting sufficient pressure and a small portion too much.

With the machine I have described we bring the pressure uniformly on the mass, after predetermining the proper pressure

to do the necessary work, and this can be varied to suit any condition, and in low-pressure work in the industries above described we reduce the moisture to 30 per cent. and lower. That means that for every ton of dried material we press out with this machine about 900 pounds of moisture more than is possible by present hydraulic open cheese presses. That means that we save the dryer in doing this work the necessity of evaporating that 900 pounds of water, less 8 per cent.

Now let us see what screw machines and roller machines will do.

These machines in beet-sugar pulp do not reduce the moisture below about 80 per cent. Beet sugar is peculiar in that the water is in the beet after the sugar is out. It is different from a material in which the water is around and about the material. In the latter gravity of mass will cause the moisture to be reduced, as in brewers' grain, but not so in beet-sugar pulp or any similar substances. It must be pressed. Each individual cossette must be pressed.

The Bergreen pattern of screw press is used here and abroad largely for this work, but they do not press below 80 per cent. moist. So for each ton of dried beet pulp there still remains 8000 pounds of water which must be evaporated by the dryers.

The hydraulic press I have described will bring this moisture down to 30 per cent. and could carry it lower. This means an actual water extraction of 7000 pounds or more per ton.

In an industry that is operating 70 factories with about 1000 tons per day per factory such economy means something. New wealth is created by such methods; it is an industrial quickening, an industrial awakening, and the dawn of a new and a brighter era.

What is true of beet sugar is true of numerous other industries.

There are 30,000,000 pounds of old rubber shoes each year that go through some sort of press to be reformed and revitalized into commercial values. Here the same economies can be effected.

There are from 2000 to 3000 breweries in this country having a valuable product in their grains. The economies effected by the machine I have described will create a large industry in expressing the moisture from the millions of bushels of barley, some of

which is now treated by expensive and inefficient liquid extractors and ineffectual dryers.

The peat bogs of the country, comprising vast areas, need but the quickening touch of an efficient and economical liquid extractor to be a source of vast wealth and a yet comparatively unborn, or at least undeveloped industry, will bloom and spring forth as one of our conspicuous staples.

The waste refuse of our civilization and particularly of our cities is laden with valuable oils and other useful products.

These by-products cannot be economically obtained without efficient pressure to separate the oils and liquids from the solid residuum associated therewith. To incinerate this material is an industrial crime, and gradually with such machinery as thus described obtainable, these products will be reclaimed, a new industry created, and the health and happiness of our people be the greater therefor.

The sea with its teeming millions of fish has ever been a source of wealth among the nations, but the oils in the fish that cannot be marketed as eatable will be marketed from many industrial establishments not yet born, but which will spring into being because profit can be made from capital engaged in the fish-oil and tankage industry with an automatic and efficient plant such as this mechanism will give.

There are about 2,500,000 tons of sugar made annually. The average of sugar contained in high-grade cane is about 21 per cent., in high-grade beet sugar 18 per cent. to 20 per cent. The value of the annual product should be about $250,000,000 if it could all be extracted, but one-half is not obtained. Possibly a scientific press room may figure in important economies in the sugar business.

With all the progress made in the years that are past, with all the accomplishment in the sciences, in the arts and in material well being, the student and thoughtful man has before him far greater possibilities than any that are history. With the keen intelligence, the irresistible ambition, the driving, pushing characteristics of well-directed energy and with the patience to go slow that we may move fast, who can measure, as a people, our achievement, and who can estimate the part that automatic, labor-saving, production-increasing machinery will play in the financial successes, the industrial battles and victories of the future!

PRESSES FOR THE EXTRACTION OF LIQUIDS.

[Report of the Franklin Institute, through its Committee on Science and the Arts, on the improvements in presses for the extraction of liquids made by Homer A. Herr. *Subcommittee:* James Christie, chairman; Tinius Olsen, Wm. H. Thorne, Thomas P. Conard, Hugo Bilgram. No. 2422.]

THE inventions of Homer A. Herr relate to presses for the extraction of liquids from various substances, and apply most especially to hydraulic presses. They comprise mechanism for automatically feeding the press, for cleaning it of the solid remains of the substance pressed, for regulating the pressure required and varying the maximum pressure desired, and varying and regulating the time during which the pressure exists, and for sustaining this maximum pressure for any desired period.

These several operations are all accomplished continuously and automatically and without any direct attention from the operator, after the mechanism is once adjusted for its purpose, thus enabling one skilled operator to attend to several presses, and dispensing with considerable manual labor, especially in the handling of material, which is frequently unattractive in character, and apparently also in imparting to the press greater certainty and precision of operation than can be realized when these operations are directed by hand.

This mechanism is fully described in U. S. letters patent Nos. 801,872 and 819,996 dated October 17, 1905, and May 8, 1906, also in two pamphlets issued by the Herr Automatic Press Company. This mechanism is so intricate that it cannot be satisfactorily described in detail verbally, therefore reference is made to the aforesaid documents for description of details.

The mechanism can be divided into three separate elements as follows:

1. The press proper, which may be of any of the usual forms of hydraulic extraction presses, but necessarily horizontal in position.

2. The mechanism for regulating and controlling the feeding, cleaning, and discharging of the material to be pressed.

3. The mechanism for controlling the intensity of the pressure, and the time it has to be sustained.

In addition to the foregoing Mr. Herr has embodied a method

of encasing or holding the material to be pressed, whereby this material is subjected to a more uniform pressure throughout its mass, than is usual in the ordinary presses, a matter of considerable importance in some of the industries. This is accomplished by enclosing the material within metallic frames which prevents the lateral spread of the material under pressure, and tends to distribute the pressure more uniformly than when the material is enveloped in the usual fabrics, and without any rigid support at the outer edges of the masses, but is free to flow in a lateral direction.

There are found in the annals of the Patent Office a few related inventions which are intended to accomplish partially some of the purposes sought by Mr. Herr, but no records can be found of any attempt so complete and thorough in their automatic actions as the devices heretofore described.

The extraction of liquids from materials is a very extensive industry, and embraces a great variety of products. Any mechanism that will expedite or economize in time or cost, will prove a direct advantage to the industrial arts and to the community. Mr. Herr's work is the result of several years of effort.

The apparatus for feeding, cleaning, and discharging the press, as illustrated by several views in Book A. having been found somewhat complex and lacking in general rigidity, Mr. Herr has constructed a simpler machine operated electrically, which appears to be an improvement on his first design.

The Subcommittee has seen these several mechanisms complete and in motion, and although Mr. Herr has not yet put these into practical operation, he has accomplished enough to make it appear probable that he has made a distinct advance in the economies of an important industry. For the skill and intelligence exhibited in developing this ingenious mechanism, the Franklin Institute suggests the recommendation of the *John Scott Legacy Medal* and *Premium* to Homer A. Herr for his improvement in presses for the extraction of liquids.

Attest: ALFRED RIGLING,
Acting Secretary.

Philadelphia, May 6, 1908.

FRANKLIN INSTITUTE

NOTE ON THE ACTION OF ALUM ON SCHUYLKILL WATER.

BY
HENRY LEFFMANN.
Member of the Institute

THE experiments described herewith were undertaken to get some information as to the operation of a mechanical filter system, installed in a large general hospital in this city. An older portion of the building had been supplied under this system for several years, and the hot water pipes had been seriously clogged and pitted. It was feared that the new installation would also be injured and it was, therefore, desired to determine the cause of the pitting and remedy it if possible. The present installation consists of two mechanical filters, installed by different companies, but operating on the same fundamental principle, although differing in some details. Both use an aluminum salt for coagulation and then force the water through a filter-bed under pressure. In addition to the injury to the pipes, it has been noted of late that the water is not efficiently filtered, the effluent being often distinctly turbid.

The installing companies have been consulted and their engineers have made reports. One expert suggests lime water in place of the aluminum solution, a method that promises well and has been a good deal used where corrosion occurs. My own relation to the case arose from the fact that I hold an honorary position on the hospital staff, and the medical director wanted my assistance. I thought it interesting to determine whether the effluent contained excess of alum, because, as an expert of a filter company once said at a meeting of the American Water-works Association, the usual plan when the effluent is unsatisfactory is "to slap in the alum."

Excess of aluminum salt may be detected by Mrs. Richards' test, but the reagent, fresh logwood chips, is not easily obtained.

As the coagulant is usually aluminum sulfate either as such or in the form of alum, it becomes possible to detect its excess by the influence on the alkalinity of the water. After trying several indicators I found most satisfaction with sodium alizarinmonosulfonate, an indicator now much used in gastric-juice analysis. This dissolves freely in water, the strong solution being dirty brown, but a few drops in 250 c.c. of Schuylkill water produce a purplish-red liquid which becomes yellow on acidifying. If aluminum sulfate or aluminum chloride is present, the solution is brownish yellow and is not changed by addition of small amounts of mineral acid.

It appeared, therefore, possible to determine easily if the automatic supply of coagulant was working properly, especially if an excess of the aluminum salt was being used. Some preliminary experiments were made by adding known amounts of alum to Schuylkill water. Crystallized ammonium alum was used, on account of its uniform quality and general purity. Amounts of it, ranging from a ratio of 1 grain per U. S. gallon to 10 grains, were added to the water, allowed to stand 24 hours, filtered through paper, and titrated. The usual method was to to take portions of 500 c.c., add the required amount of alum dissolved in a little distilled water, and after 24 hours, filter, collect 250 c.c. of filtrate, and titrate this. It was found that the untreated water required a little over 2 c.c. of decinormal sulfuric acid. This was a supply at the Woman's Medical College. Experiments made in the centre of the city show practically the same alkalinity. I found that as much as 9 grains of crystallized ammonium alum can be added to Schuylkill water without overcoming the alkalinity or leaving unchanged alum. I was somewhat astonished at these results, but on calculation of the respective molecular weights the fact is explained. One molecule of alum will react with 3 molecules of any of the normal carbonates, hence 9 grains of crystallized ammonium alum will decompose the following amounts approximately:

Calcium carbonate	3 grains
Magnesium carbonate	2.5 grains
Potassium carbonate	4 grains
Sodium carbonate	3 grains

At my suggestion, a series of daily tests was made on the applied and effluent water at the hospital. As the data were

merely relative, arrangements were made to have a uniform volume of water tested with acid of uniform strength. The figures have, therefore, no absolute value, but are very instructive relative data. Dr. Funke, the chemist in charge of the hospital laboratory, made a considerable number of tests, of which a few are here appended. The figures are the c.c. of acid required to produce an acid reaction to the alizarin reagent.

Date	Raw water	Effluent
11	2.85	0.75
12	2.85	2.6
13	2.9	1.6
15	2.85	0.5
16	2.7	1.75
17	3.0	1.1
18	2.8	1.5
23	3	1.9
25	3.5	2.55

The figures show the comparatively slight variation in the alkalinity of the water, and the great variability of the alum feed, indicating that the operation of the filter requires much more careful supervision than it is receiving.

RUBBER-TANNED LEATHER.

A BRITISH publication states that a new syndicate has established a factory in London and is placing upon the market a new form of leather, for which it is claimed there is a big future, and which it thus describes:

The leather is submitted to a tanning process of the chrome variety, which preserves it; rubber solution is then worked into the interstices, rendering the hide thoroughly waterproof. The elasticity of the rubber permits of perfect flexibility and extraordinary toughness of some of the skins, especially of rabbit, goat, and sheep skins. It is impossible to forecast the many uses for which this process may be available. Tests have been made for motor tires, soles for boots and shoes, pump washers, machine belting, miners' boots, etc., and it is probable that the multitude of articles that can be made of rubberized leather will, in time, create a further demand for rubber. This new material, it is thought, may also prove useful for motor and cycle tires, as it is almost impossible to puncture it, while it is said to be much more resilient and waterproof than ordinary leather.

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FRANKLIN INSTITUTE

(Proceedings of the stated meeting held Wednesday, March 17, 1909.)

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, March 17, 1909.

President WALTON CLARK in the Chair.

Present, seventy members and visitors.

Additions to membership since last report, four.

The Chairman introduced Mr. J. Kent Smith, Chief Metallurgist of the American Vanadium Company, Pittsburg, Pa., who spoke on the subject of vanadium and its applications to the heavy arts. The lecturer reviewed the history of the metal and described its modes of occurrence and its present sources of supply. Steel as normally constituted was considered and the effects produced upon it by vanadium. Results of tests of vanadium steel and its behavior in actual service were shown. The subject was illustrated by lantern slides and numerous specimens. Mr. Smith then called upon Mr. E. Warren Wilson, President of the Union Saw Company, Williamsport, Pa., who gave an interesting exhibition of saws made of vanadium steel.

The next speaker of the evening, Mr. Albert Stetson, of New York, described the Shore scleroscope, a direct reading instrument for testing the hardness of metals and other solid bodies. The apparatus was exhibited by Mr. Albert F. Shore, the inventor.

At the close of the meeting a vote of thanks was tendered the speakers. The two subjects presented were referred to the Committee on Science and the Arts for investigation and report, and the lecture on vanadium was referred for publication. Adjourned.

JAMES CHRISTIE,
Secretary.

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